TRANSVERSE PLATE FLOORS DESIGN RECOMMENDATIONS IN FATIGUE SCENARIO FOR ALTERNATIVE CONFIGURATIONS IN PANAMAX CONTAINER SHIPS

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Keywords

Fatigue, Transverse plate, Finite element analysis, Container ship.

Abstract

The objective of the survey is to evaluate within the field of structural fatigue behavior, various alternative configurations of transverse plate floors in Panamax container ships. Analysis purpose could be within the current regulatory framework, a possible contribution of recommendations in the development standards for the design of this type of structures in one of the vessels with the greatest presence in the international market. The recommendations and possible alternative designs are analyzed through numerical simulations with "Ansys" software and real scale tests. The aim is to understand the fatigue behavior of these alternative designs in the face of axial stress and bending scenarios. The development has been structured mainly in two stages. First stage: once the permissible limits have been established by the regulatory framework, we establish a set of alternative designs for the enveloping structure of the transverse plate floors which is made up of the longitudinal, bottom, double bottom and side girders. Second stage: to establish a set of alternative transverse plate floors corresponding to each of the enveloping structures generated in the previous stage and proceed with the study of all these alternative designs. All the proposed alternatives, a large amount of data and alternative sections has been obtained through numerical simulations with "Ansys" software. In principle some of them show according with simulations interesting structural properties and better behavior in fatigue scenarios with respect to the initial typical distribution.

Paper structure

1 INTRODUCTION

Global trade and transport have developed exponential growth in recent decades generating an increase in the number and size of container ships [ref1] and [ref2].

Defined as a "Twenty-foot equivalent unit", the payload capacity of the container carrier fleet has been increased [ref 3]. Within this increase various types of container ships have also increased according to their different payload volumes [ref 4].

At present there is a possible classification of various types of container ships and their corresponding equivalence between their TEU payload and their denomination (Panamax, Ultra Large Container Vessel), with the Panamax class being one of the greatest presence as well as a conservative trend [ref 5].

As a result of the increase in the international market and consequently the increase in the number of vessels that make up the container ship fleet worldwide, the number of studies and articles has also increased.

That increase has not only occurred in the number of publications, but also in the diversity of their content, covering a great variety of topics to be developed such as: design safety margin of a container ship [ref 6], the competitiveness of alternative routes in the container ship trade [ref 7], strength of the hull beam assembly [ref8], resistance combined with the effects of lateral pressure [ref9], study of design recommendations under the action of fatigue [ref10], torsion study of the hull beam assembly of container ships with large openings [ref11], transport during the Covid-19 situation [ref12], solution for a retrofitted in container ship [ref 13] among others.

With the aim of continuing this trend of container ships and being transverse plate floor a fundamental part of the structural assembly of any ship, this study aims to obtain a set of sections and transverse plate floors permissible by the regulatory framework of the classification societies of a Panamax type container ship, as well as its response to the shear stress scenarios, bending moment scenarios and fatigue. In this way, these configurations that have got better qualities could be shown as possible valid alternatives in design process of container ship vessels.

With this objective of obtaining possible alternative designs, the development process [Figure 1] of this study is structured in a series of points.

First point is starting from a well-defined and correctly referenced container ship design. In this aspect, it is necessary to locate project design and to obtain the necessary data from it. These elements are the main structural elements such as main frame, sections formed by the union of the bottom, double bottom, side girders, longitudinal and transverse plate floors specially, which is the main objective of the study. Transverse plate floor could be defined as the structural element delimited by the section comprising of bottom, double bottom, side girders, longitudinal and all of them constitute a significant part of the vessel main frame.

Subsequently it is necessary to define regulatory framework that regulates set of permissible modifications of these original structural elements. As a container ship, main sources of regulations are "Iacs" and classification societies such as "Lloyd's Register of shipping" standars. Within these rules, main application are those that regulate design of main frames and the physical properties that they must comply with. It is also necessary those that regulate design of plates and lightening, and especially those regulations that define calculation of the efforts suffered in the main frames of container ships and their subsequent design.

Next, once there is an initial point as a vessel, also its structural elements, values of the forces to which it is subjected and the regulatory framework that regulates the values that these structural elements may acquire, it is proceed with the study/design of possible alternatives to these initial structural elements. Although the final objective of this study is transverse plate floors, a prior study is necessary of the section that delimits it.

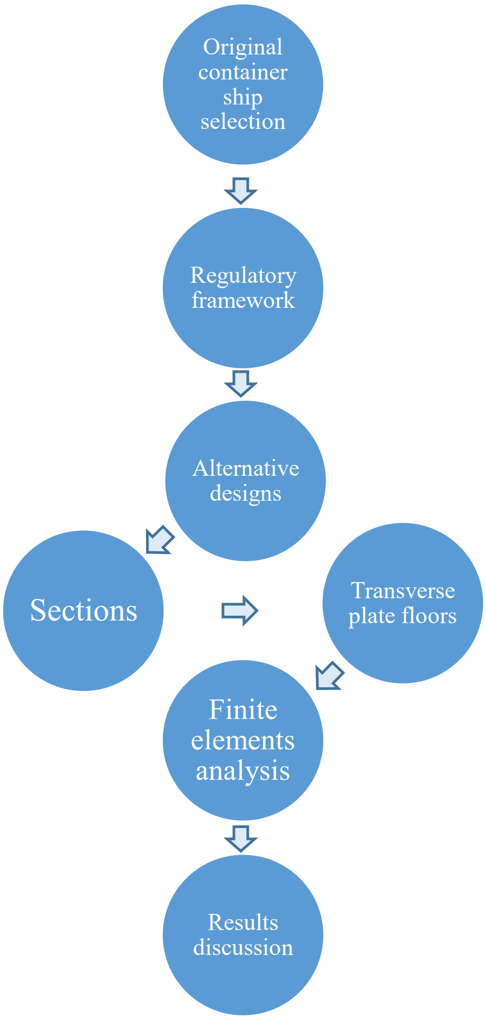


Figure 1 Development process

Therefore at this point, the first study to be carried out is on the permissible alternatives of the section that delimits transverse plate floors, the one made up of a bottom, double bottom, side girders and longitudinal. Starting from the initial section of the selected vessel and applying regulations, alternative designs of this type of section are established and each of them will subsequently generate alternative designs of the original transverse plate floor.

Once the alternative designs of the sections that delimit transverse plate have been defined in accordance with the regulations, possible alternative designs of the original one are generated using as well previous indicated regulations. In total, 72 different alternative designs of the original transverse plate are generated as a combination among others of number and positions of longitudinal, morphology of them, cut outs and thicknesses.

Once these possible alternative designs of the original transverse plate floor have been established, virtual models of each of them are generated and numerical simulations of finite elements are carried out using the "Ansys" software, simulating scenarios of shear stress and bending moment as well as fatigue in each one of these scenarios.

Finally it is proceed with analysis and comparison of obtained results from numerical simulations of the alternative designs with respect to the original design. In this way try to achieve the initial objective of this study as a search for possible transverse plate floor alternative designs that may present better structural behavior compared to the original design.

2 ORIGINAL CONTAINER SHIP SELECTION.

At this point the objective is to select and reference a design belonging to the type of vessel under study. First of all to obtain a main frame dimension. From it to know positions of the main structural elements such as longitudinal, side girders, bottom and double bottom. Subsequently each of these types of profiles as well as the thicknesses of plates. Next, to obtain all the references of the transverse plate floor, especially its thickness, number and type cut outs. Once this data is collected, the next point is to know scenarios for which they are designed. In other words to know foreseeable efforts values that vessel will have to face. In this way there are original dimensions and scenarios, on which to carry out study of alternative designs.

2.1. Original main frame and transverse plate floor.

In this point main frame and transverse plate floor are referred.

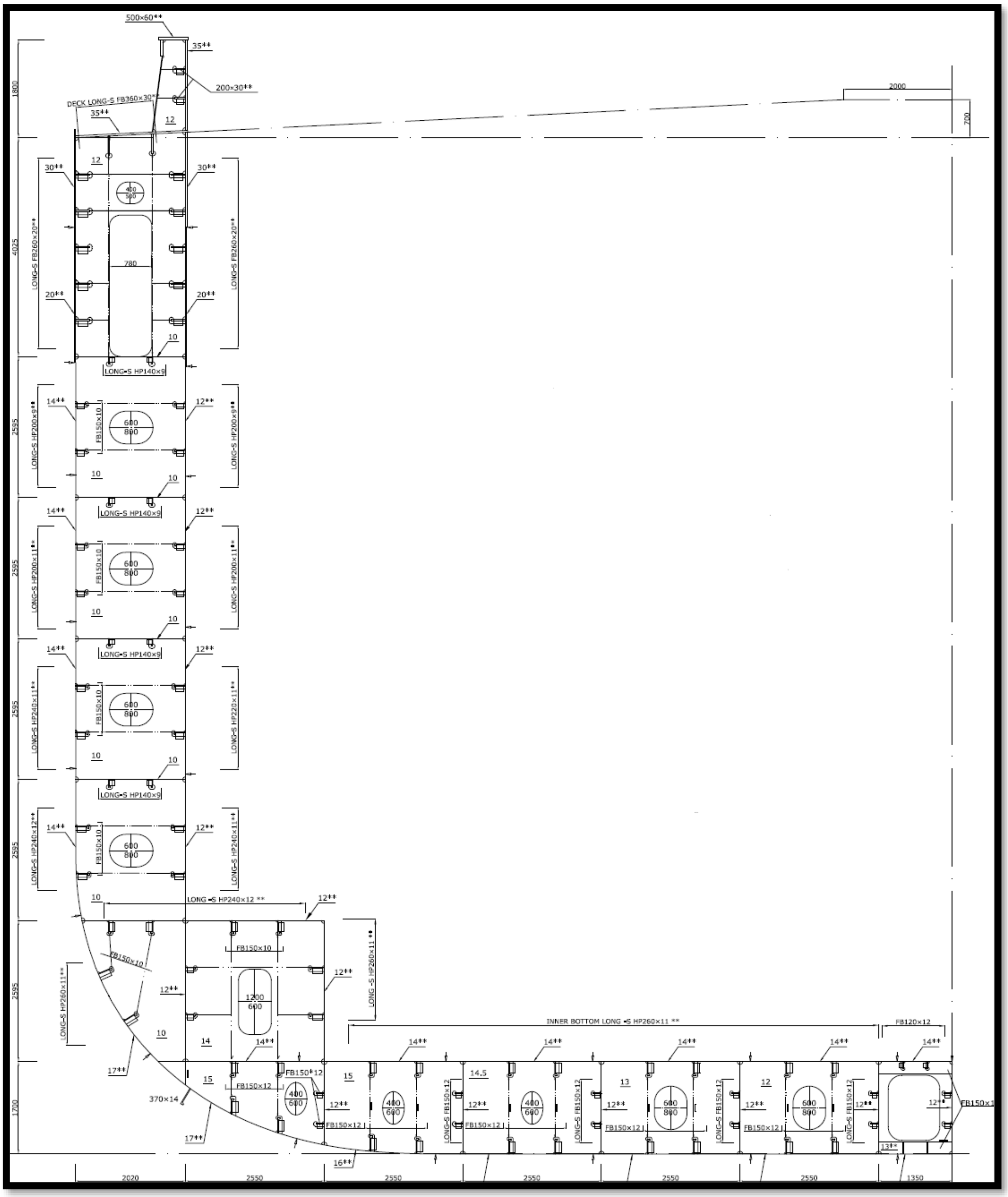


Figure 2 Panamax ship original main frame

The original vessel is container ship Panamax 3100 TEU [ref14].

Original section and transverse plate floor are shown in [Figure 2]. Across [Figure 3] a visual reference of a transverse plate floor it is shown.

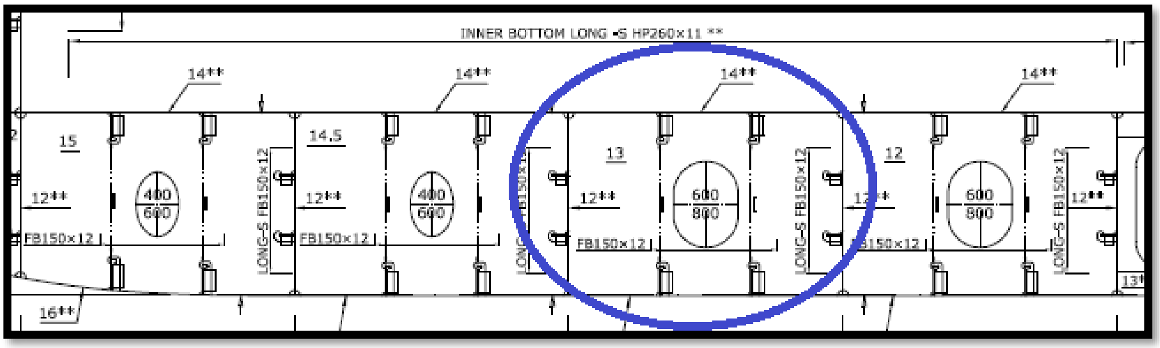


Figure 3 Original section and transverse plate floor

2.2. Original structure properties.
The objective of this point is to obtain numerical values of the stresses in the frames/sections of the original selected vessel. These values are obtained from the reference document [ref14].

Bending moments and shear stresses in still water.
The maximum values of bending moments, shear stress and torsional forces according to the regulations applied in the reference document:

Maximum positive bending moment: 1875864 KN*m

Maximum negative bending moment: -1154759 KN*m

Maximum positive shear stress: 35431 KN

Maximum negative shear stress: -31641 KN

Total bending moments and shear stresses
Maximum bending moments and shear stresses values which main frame is subjected in load conditions:

Maximum positive bending moment: 3650000 KN*m

Maximum negative bending moment: -3350000 KN*m

Maximum positive shear stress: 57500 KN

Maximum negative shear stress: -38500 KN

Inertia moments and section modulus in the original main frame.
The values collected from the reference document are:

Inertia moment: 188463 m^4

Height reference axis: 7.888 m

Section modulus top side: 15028 m^3

Section modulus low side: 23892 m^3

Necessary section modulus top side:14957 m^3

Stress status in the original main frame: bending moments.

$$\sigma_{\max top\ side}\ (+)\text{: 242 MPa}$$

$$\sigma_{\max low\ side}\ (-)\text{: -223 MPa}$$

$$\sigma_{\max top\ side}(+)\text{: 152 MPa}$$

$$\sigma_{\max low\ side}\ (-)\text{: -140 MPa}$$

Main values are shown in [Table 1]

Max bending moment(+) **KN*m**	**Z top side** **m3**	**Z low side** **m3**	**σ top side** **N/mm2**	**σ low side** **N/mm2**
3650000	15028	23892	242,87	152,77
Max bending moment(-) **KN*m**	**Z top side** **m3**	**Z low side** **m3**	**σ top side** **N/mm2**	**σ low side** **N/mm2**
-3350000	15028	23892	-222,91	-140,21

Table 1 Reference values of main frame

Stress status in the original main frame. shear stress.

$$\tau_{\max center}(+)\text{: 46 MPa}$$

$$\tau_{\max center}(-)\text{: }-31\text{ MPa}$$

Main values are shown in [Table 2]

Max shear stress (+) **KN**	**τ** **MPa**
57500	46
Max shear stress (-) **KN**	**τ** **MPa**
-38500	-31

Table 2.Reference values

Selected Material & Properties.
According to the reference document, selected materials:

- Steel grade: AH - $R_{eH}, \frac{N}{mm^2} = 355$
- Steel grade: A - $R_{eH}, \frac{N}{mm^2} = 235$

In this way structural data of the original design have been obtained as well as data on the efforts that these elements have to withstand, so this is the starting point from which to carry out studies of possible alternative designs to this original.

3 REGULATORY FRAMEWORK

Once initial type of vessel is known and elements to be analyzed as possible alternatives, it proceeds to obtain regulatory framework of them. The objective is to establish limits to validate the alternatives that are derived from the study. The main regulations used come from "Iacs" and Classification Societies. Within all the regulations, it is establish those specific to each analyzed element.

3.1. Main frame container ship:

At this point, the objective is to reference applicable regulations regarding the stresses to which the sections/frames of container ships are subjected. Reference are [ref18].

Reference standards: Iacs_S11A_2.Loads.
Within the S11A standard "container ships longitudinal strength", its section number two establishes and analyzes the different sections in which hull beam assembly tension state in container ships is organized.

Reference standards: iacs_S11A_2.1.Sign convention for hull girder loads.
The rules are established regarding the convention of signs positive and negative in shear forces and bending moments.

Reference standards: iacs_S11A_2.2.Still water bending moments and shear force.
Bending moments and shear stresses in calm water must be calculated in each section along the hull beam assembly under each of the specific load conditions.

$\boldsymbol{M_{Smax}}$: Maximum bending moment in still water $\boldsymbol{M_{Smin}}$: Minimum bending moment in still water.

$\boldsymbol{F_{Smax}}$: Maximum shear stress moment in still water. $\boldsymbol{F_{Smin}}$: Minimum shear stress moment in still water.

Reference standards: iacs_S11A_2.3.1.Wave parameters.
In this section the influence of waves is established. The procedure is started by calculating the wave parameter as a function of wave lengths.

Reference standards: iacs_S11A_2.3.2.Vertical wave bending moments.

$$\text{Bending moments in hogging: } \boldsymbol{M_{W\_Hog}} = 1.5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL\_Hog}$$

$$\text{Bending moments in sagging: } \boldsymbol{M_{W\_Sag}} = -1.5 f_R L^3 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL\_Sag}$$

Reference standards: iacs_S11A_2.3.3.Vertical wave shear force.

$$\text{Shear force at aft, hogging: } \boldsymbol{F^{Aft}_{W\_HOg}} = 5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} \left(0.3 + 0.7 f_{NL\_Hog}\right)$$

$$\text{Shear force at fore, hogging: } \boldsymbol{F^{Fore}_{W\_HOg}} = -5.7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} f_{NL\_Hog}$$

$$\text{Shear force at aft, sagging: } \boldsymbol{F^{Aft}_{W\_Sag}} = -5.2 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} \left(0.3 + 0.7 f_{NL\_Sag}\right)$$

$$\text{Shear force at fore, sagging:} \boldsymbol{F^{Fore}_{W\_Sag}} = +5.7 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8} \left(0.25 + 0.75 f_{NL\_Sag}\right)$$

$$\text{Shear force at middle :} \boldsymbol{F^{Mid}_{W}} = 4 f_R L^2 C C_W \left(\frac{B}{L}\right)^{0.8}$$

Reference standards: iacs_S11A_2.4.Loads cases.
The maximum and minimum values of bending moments and shear stresses as a combination of still water and wave influence must be higher than the values of bending moments and shear stresses corresponding to each of the load conditions.

3.2. Sections:
The objective is to reference applicable regulations in sections defined as set of two side girders, bottom, double bottom and the longitudinal of container ships. Reference are [ref17], [ref18], [ref19].

Reference standards: S11A_2.5.Hull girder stress.
This standard refers to the value of the normal and tangential stress of the mid-section of the ship. Highlight the importance of the section module in the calculation of these values. According to this standard, the value of the stresses in the mid-section must not be higher than that obtained from said standard.

$$\boldsymbol{\sigma_{HG}} = \frac{\gamma_S Ms + \gamma_W Mw}{Inet}(Z - Zn)10^{-3} \quad \boldsymbol{\tau_{HG}} = \frac{\gamma_S Fs + \gamma_W Fw}{\frac{t_{net}}{q_v}}10^{-3}$$

Reference standards: S11A_3.2.Stiffness criterion.
This standard establishes the value that the inertia moment must meet in sheer and break loading conditions.

$$I_{net} \geq 1.55\, L\, |M_s + M_W| 10^{-7}$$

According regulations, new sections won´t have inertia moments that are not lower than the initial one.

Reference standards. S11A_3.3.Yield strength assessment.
This standard establishes that the equivalent elastic limit in each loading condition must be lower than the allowable one.

$$\boldsymbol{\sigma_{eq}} = \sqrt{\boldsymbol{\sigma_x^2 + 3\tau^2}} \qquad \boldsymbol{\sigma_{perm}} = \frac{\boldsymbol{R_{eH}}}{\boldsymbol{\gamma_1\gamma_2}} \qquad \boldsymbol{\sigma_{eq}} < \boldsymbol{\sigma_{perm}}$$

According to the presented standard, the new sections must be made of a material with a load/resistance of elastic limit that cannot be lower than the initial of the original section.

Reference standards: S7 Minimun longitudinal strength standards.
This standard establishes the minimum value of the section modulus in vessels that are not CSR Bulk Carriers or Oil Tankers.

$$\boldsymbol{W_{min}} = c\, L^2 B\, (C_b + 0.7)\, k\, (cm^3)$$

According to regulations presented, new sections cannot have section modules lower than the original.

Reference standards. S21A_1.4.General requirements.
This standard establishes the spacing of primary supporting members parallel to the direction of secondary stiffeners is not to exceed 1/3 of span primary supporting members. According regulation, new sections must be made up of a number of longitudinal in each subsection not less than two.

3.3. Transverse plates:
The objective is to reference applicable regulations in transverse plate floors Reference are [ref20], [ref21] and [ref22].

Reference standards: Lloyd´s, rules and regulations for the classification of naval ships 2022_prt3, chapter 10, section 5.2.
On part3, chapter 10, section 5.2. [ref20] is established regulation about arrangements at intersections of continuous secondary and primary members.

Reference standards: Iacs, Common structural rules for bulk carriers and oil tankers_part 1, chapter 3, section 6.
Although it is a fact that these rules belonging to the "Common Structural rules for bulk carriers and oil tankers" [ref22] it is highlight the great similarity between the values established in this regulation and the previous ones previously reviewed.

Reference standards: Lloyd´s, rules and regulations for the classification of naval ships 2022_volume 1,prt3, chapter 2, section 3.2.9.
Regulation [ref21] establishes recommendations about holes and opening in web or primary members.

4 ALTERNATIVE DESIGNS

Once type of ship to be studied and frame regulatory are established, the next point is to study various alternative configurations of transverse plate floors.

However, these alternatives must not involve a substantial modification of the structural characteristics of the rest of the elements that make up the structural assembly of the ship, and they must comply with the standards of the classification societies.

Development of this point consist in:

- Sections alternative designs.
- Transverse plate floor alternative designs.
- Finite element analysis numerical simulation.

The process consists in establishing alternative designs of the section that delimits the original transverse plate floor. Subsequently, generate alternative plates designs for each alternative section and finally perform numerical simulations using finite element analysis.

4.1. Sections: alternative designs.

Transverse plate floor [Figure 4] is defined as the structural element placed between two side girders, bottom, double bottom and longitudinal elements arranged around them.

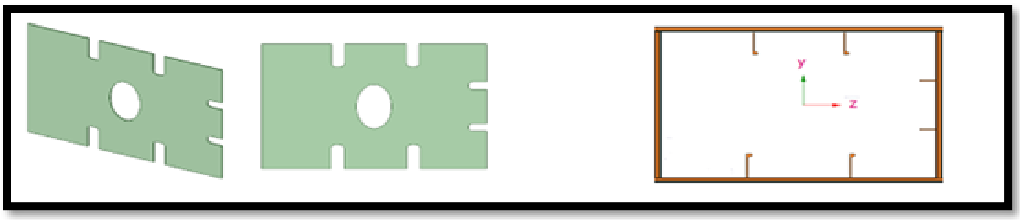


Figure 4 Transverse plate floor and section

It will be named this set of elements that define transverse plate floor as section.

Once a section of the ship type under study is established, the objective is to find and study various configurations of the section, obtained as the combination of various layouts, locations and types of the longitudinal elements that make it up but keeping everything under the regulation.

All previous processes, such as the calculations of bending moments and shear forces in each of the loading conditions are not carried out/considered in this study, that data comes from the referenced previous project [ref14].

About development and work methodology, as a first step from the initial section of the known ship which is made up of:

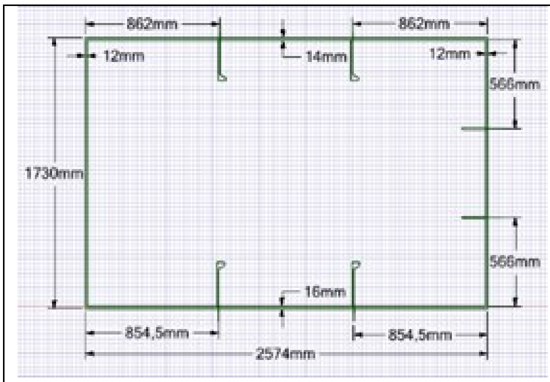
- Section modulus.
- Double bottom with 2 longitudinal HP280X11.
- Bottom with 2 longitudinal HP260X11.
- Side girders with 2 longitudinal FB150X12.

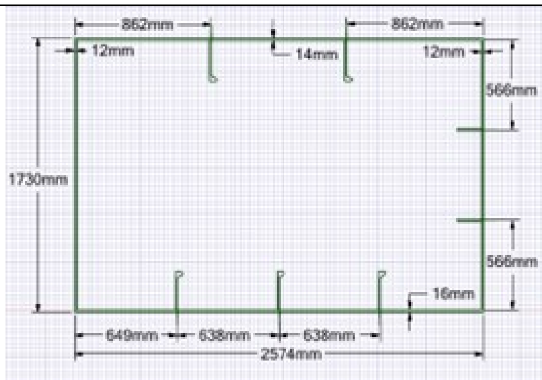
It is established a record where the profiles HP280X11, HP260X11, FB150X12 are collected from [ref15] and [ref16], as well as profiles of a higher and lower order than these initial ones.

In the double bottom, bottom, and side girder of the initial section, the number of longitudinal is increased in each of them, generating a number of new configurations.

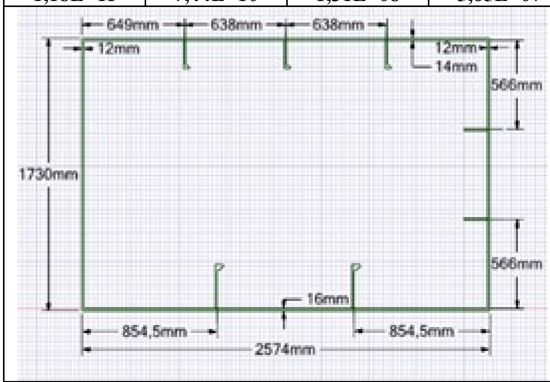
For each of these new configurations, it is established each of all the lower profiles "HP" and FB" collected in the record and calculate the section module of each of all these configurations.

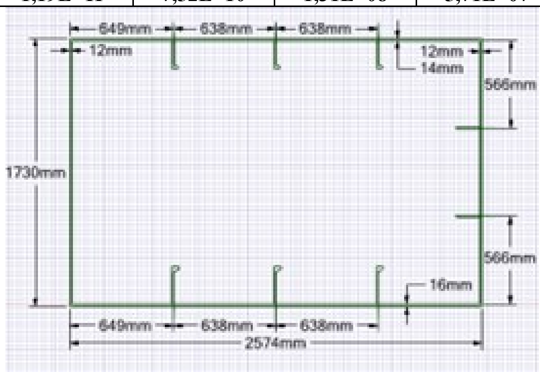
Finally, those configurations where the section modulus are immediately above of the initial section are collected [Table 3].



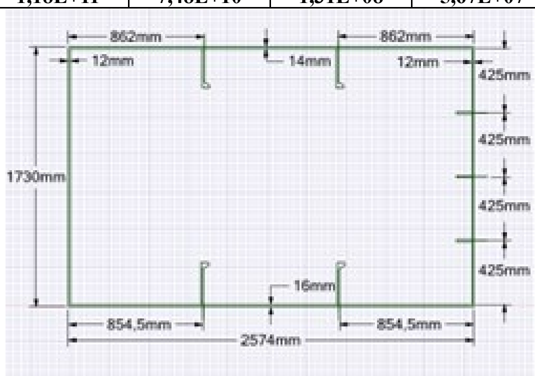


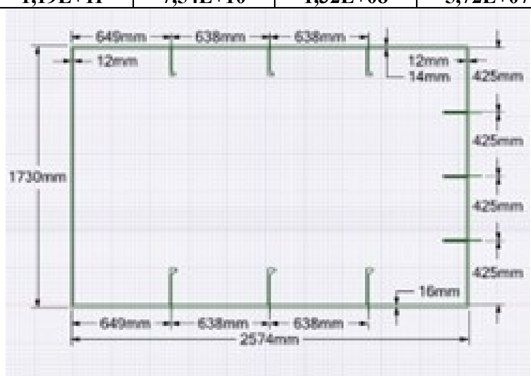
section	double bottom longitudinal	bottom longitudinal	side longitudinal	section	double bottom longitudinal	bottom longitudinal	side longitudinal
1	**HP280X11**	**HP260X11**	**FB150X12**	**2**	**HP240X10**	**HP260X11**	**FB150X12**
inertia moment Iy mm4	**inertia moment Iz mm4**	**section modulus Zy mm3**	**section modulus Zz mm3**	**inertia moment Iy mm4**	**inertia moment Iz mm4**	**section modulus Zy mm3**	**section modulus Zz mm3**
1,18E+11	**7,44E+10**	**1,31E+08**	**5,65E+07**	**1,19E+11**	**7,52E+10**	**1,31E+08**	**5,71E+07**





section	double bottom longitudinal	bottom longitudinal	side longitudinal	section	double bottom longitudinal	bottom longitudinal	side longitudinal
3	**HP280X11**	**HP180X11**	**FB150X12**	**4**	**HP240X10**	**HP180X11**	**FB150X12**
inertia moment Iy mm4	**inertia moment Iz mm4**	**section modulus Zy mm3**	**section modulus Zz mm3**	**inertia moment Iy mm4**	**inertia moment Iz mm4**	**section modulus Zy mm3**	**section modulus Zz mm3**
1,18E+11	**7,48E+10**	**1,31E+08**	**5,67E+07**	**1,19E+11**	**7,54E+10**	**1,32E+08**	**5,72E+07**





section	double bottom longitudinal	bottom longitudinal	side longitudinal	section	double bottom longitudinal	bottom longitudinal	side longitudinal
5	**HP280X11**	**HP260x11**	**FB100X12**	**6**	**HP240X10**	**HP180X10**	**FB150X9**
inertia moment Iy mm4	**inertia moment Iz mm4**	**section modulus Zy mm3**	**section modulus Zz mm3**	**inertia moment Iy mm4**	**inertia moment Iz mm4**	**section modulus Zy mm3**	**section modulus Zz mm3**
1,18E+11	**7,46E+10**	**1,31E+08**	**5,65E+07**	**1,20E+11**	**7,54E+10**	**1,32E+08**	**5,70E+07**

Table 3 Sections: alternative designs

4.2. Transverse plate floor: alternative designs.
Once the different sections have been defined [Figure 5], it proceed to generate the different types of transverse plate floor related to each section.

Transverse plate floor can be defined as the structure delimited by the section, or defined as the structural element between two side girders, bottom, double bottom and the longitudinal elements arranged around .

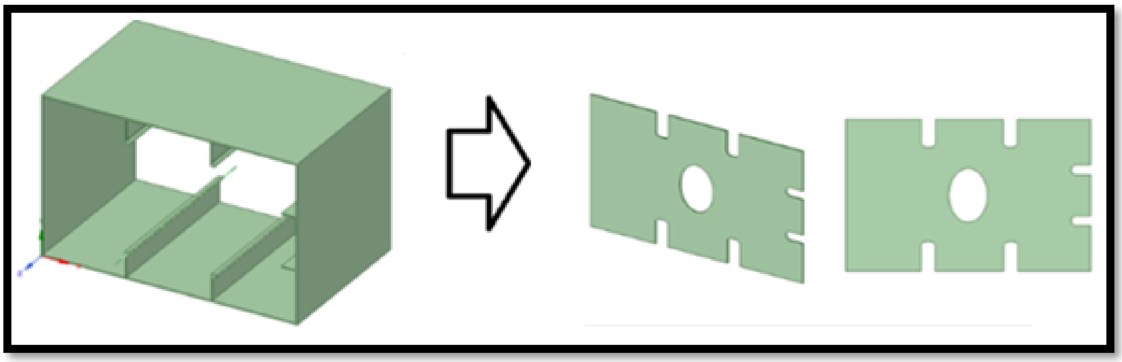


Figure 5 Transverse plate floor procedure

The different transverse plate floor are mainly defined as combination of: section, cut-outs, holes geometry, thickness among others.

About development and work methodology of different transverse plate floor is done as combination of:

- Section: 6 different types of them previously stablished, [Figure 6].

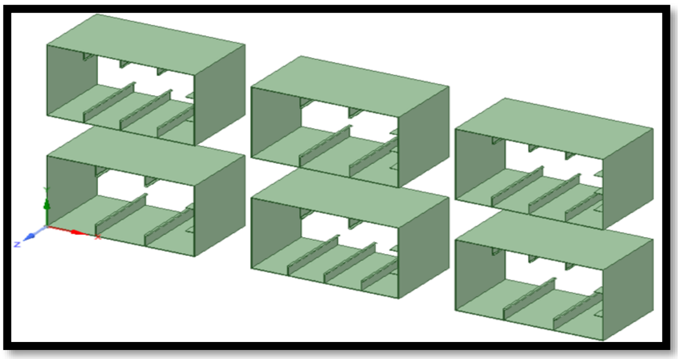


Figure 6 Sections

- Cut outs: 4 different types [Figure 7].

Figure 7 Cut outs

- Thickness: 3 different types: 14,5 mm 18mm and 22 mm.

As result of all combinations, it is obtained 72 different transverse plate floor [Table 4].

All 72 transverse plate floor alternative designs are attached in [Annex I.

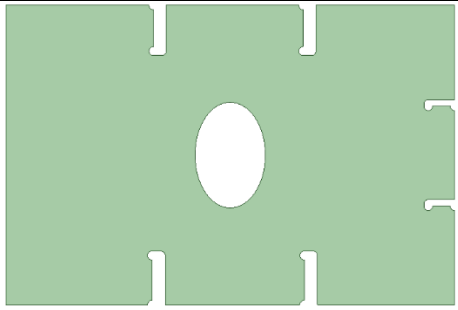
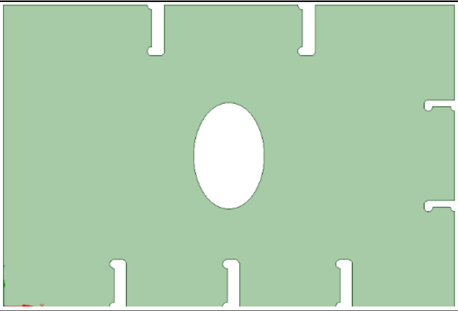
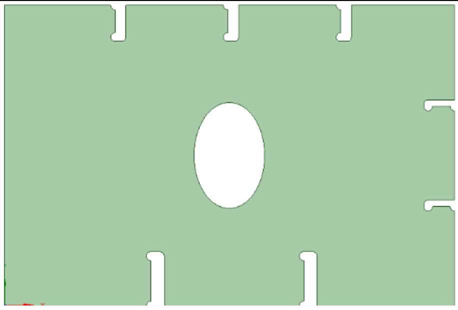
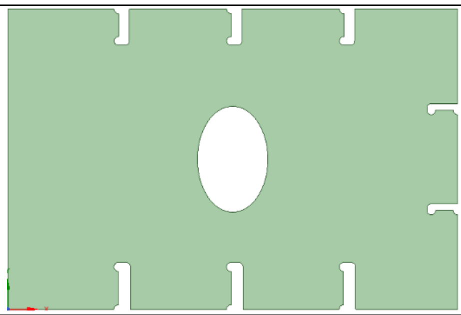
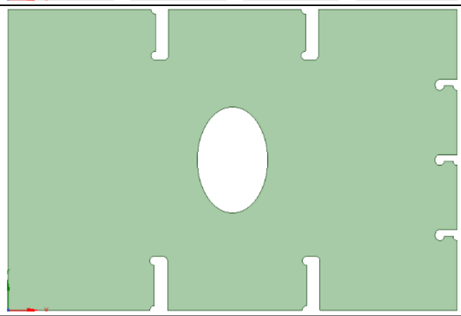
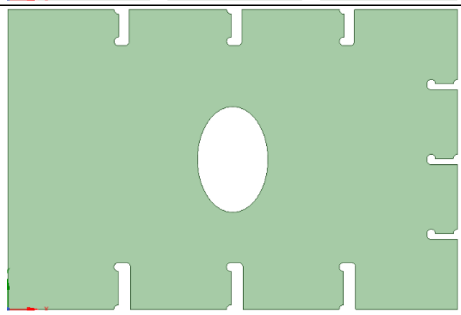
models	sections	cut outs	sketch/ cut outs	thickness	sketch
model 1		A		14,5 mm	
model 2		A		18 mm	
model 3		A		22 mm	
model 4		B		14,5 mm	
model 5		B		18 mm	
model 6	1	B		22 mm	
model 7		C		14,5 mm	
model 8		C		18 mm	
model 9		C		22 mm	
model 10		D		14,5 mm	
model 11		D		18 mm	
model 12		D		22 mm	
model 13		A		14,5 mm	
model 14		A		18 mm	
model 15		A		22 mm	
model 16		B		14,5 mm	
model 17		B		18 mm	
model 18	2	B		22 mm	
model 19		C		14,5 mm	
model 20		C		18 mm	
model 21		C		22 mm	
model 22		D		14,5 mm	
model 23		D		18 mm	
model 24		D		22 mm	
model 25		A		14,5 mm	
model 26		A		18 mm	
model 27		A		22 mm	
model 28		B		14,5 mm	
model 29		B		18 mm	
model 30	3	B		22 mm	
model 31		C		14,5 mm	
model 32		C		18 mm	
model 33		C		22 mm	
model 34		D		14,5 mm	
model 35		D		18 mm	
model 36		D		22 mm	
model 37		A		14,5 mm	
model 38		A		18 mm	
model 39		A		22 mm	
model 40		B		14,5 mm	
model 41		B		18 mm	
model 42	4	B		22 mm	
model 43		C		14,5 mm	
model 44		C		18 mm	
model 45		C		22 mm	
model 46		D		14,5 mm	
model 47		D		18 mm	
model 48		D		22 mm	
model 49		A		14,5 mm	
model 50		A		18 mm	
model 51		A		22 mm	
model 52		B		14,5 mm	
model 53		B		18 mm	
model 54	5	B		22 mm	
model 55		C		14,5 mm	
model 56		C		18 mm	
model 57		C		22 mm	
model 58		D		14,5 mm	
model 59		D		18 mm	
model 60		D		22 mm	
model 61		A		14,5 mm	
model 62		A		18 mm	
model 63		A		22 mm	
model 64		B		14,5 mm	
model 65		B		18 mm	
model 66	6	B		22 mm	
model 67		C		14,5 mm	
model 68		C		18 mm	
model 69		C		22 mm	
model 70		D		14,5 mm	
model 71		D		18 mm	
model 72		D		22 mm	

Table 4 Transverse plates floor: alternative designs

4.3. Finite element analysis: numerical simulation and achieved results.

Once it is stablished the type vessel of object study, frame regulatory, alternative sections to the original, and various transverse plate floor, the next point is to develop the tests to be carried out on the alternative plates designs. Numerical simulations by finite elements analysis are carried out for each of the 72 alternative transverse plate floor designs using "Ansys" software. These simulations apply shear stresses and bending moments scenarios obtaining from each of them the value of stress, strain, deformation and nºcycles in fatigue life.

4.3.1.Numeric simulations. Response under shear stress.

Initial *model.*

Initial model [Figure 8] is established in "ansys" software.

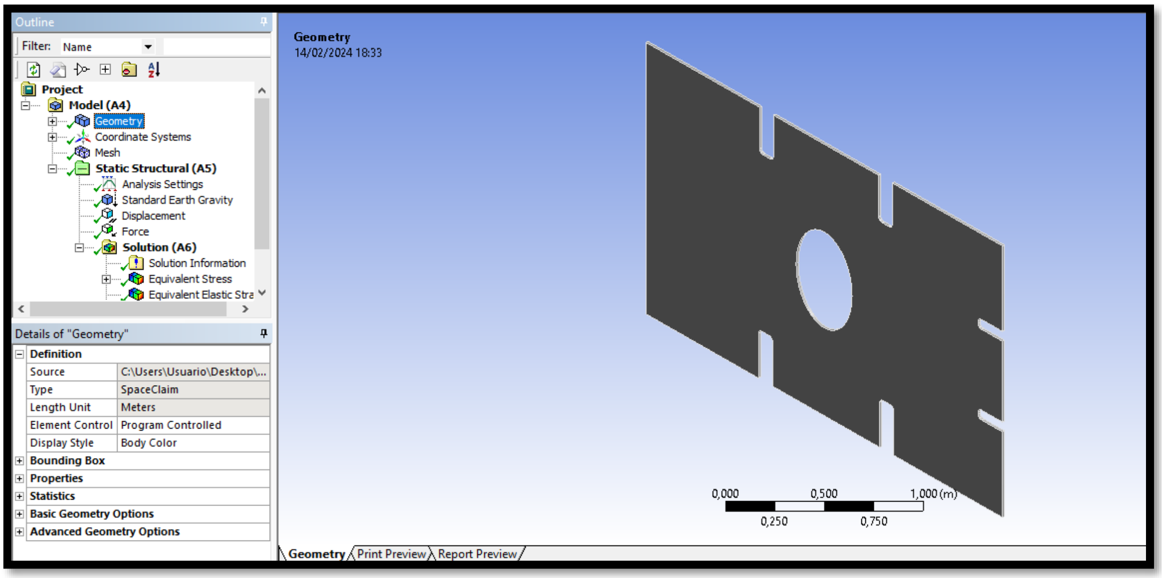


Figure 8 3d model

Mesh.

Mesh [Figure 9] that "ansys" program creates by default.

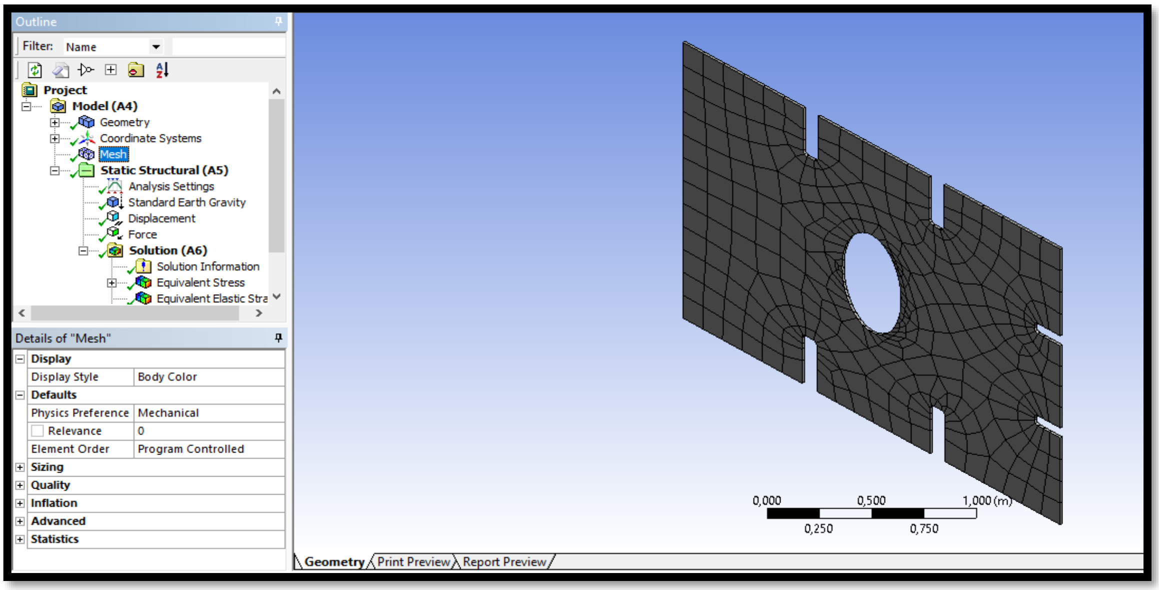


Figure 9 Initial model mesh

Subsequently, this mesh will be refined based on complying with convergence process.

Boundary conditions.

In reality, a transverse plate floor is welded to the bottom, double bottom and side girders.

Boundary conditions are established that could be easily recreated in the laboratory in a possible future scale test [Figure 10].

Boundary conditions are:

Side A: range of movement (free, free, free).

Side B: range of movement (0, 0, 0).

Side C: range of movement (free, free, free).

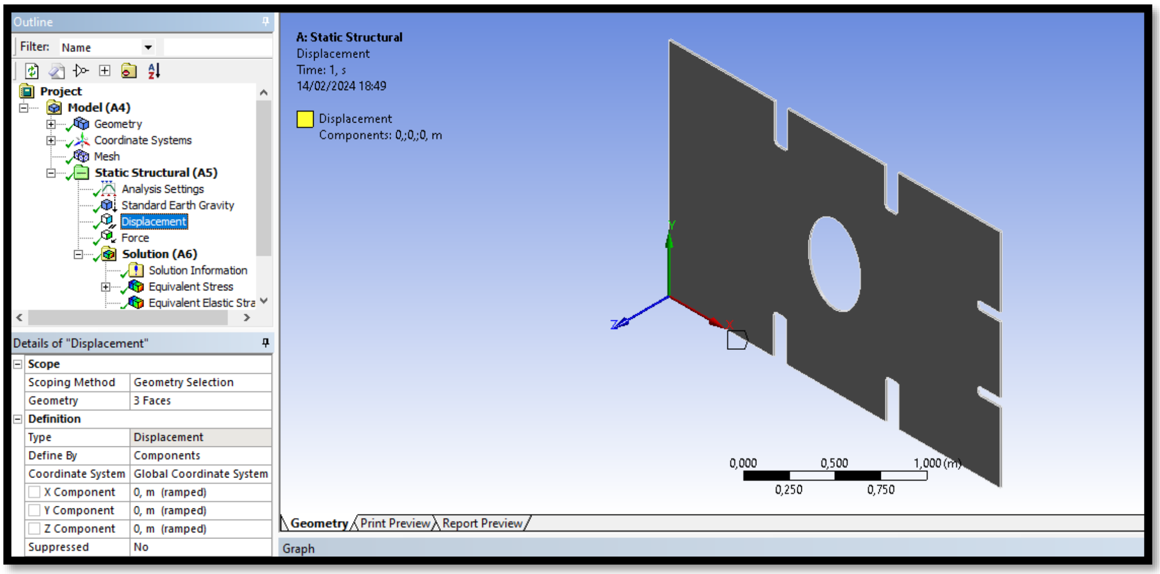


Figure 10 Boundary conditions

Loads.

At this point analysis of loads that shear forces on the hull beam assembly generate in the main frame according Collignon-Jourawski theorem is developed.

Main values are referenced in [Figure 11] and obtained from [ref14].

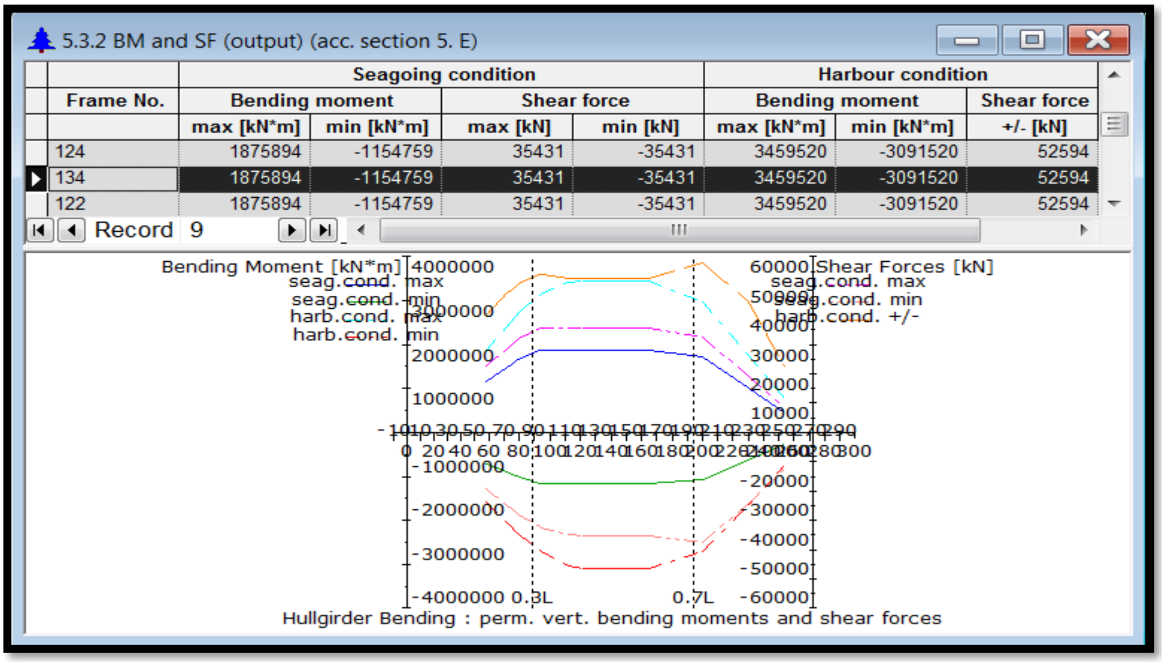


Figure 11 Shear forces referenced

Maximum shear stress =57500 KN

Maximum stress = 46 MPa

In order to subsequently carry out a laboratory test, it is applied a force that could be emulated in the subsequent test, [Figure 12].

Load = 600 KN (0,1,0)

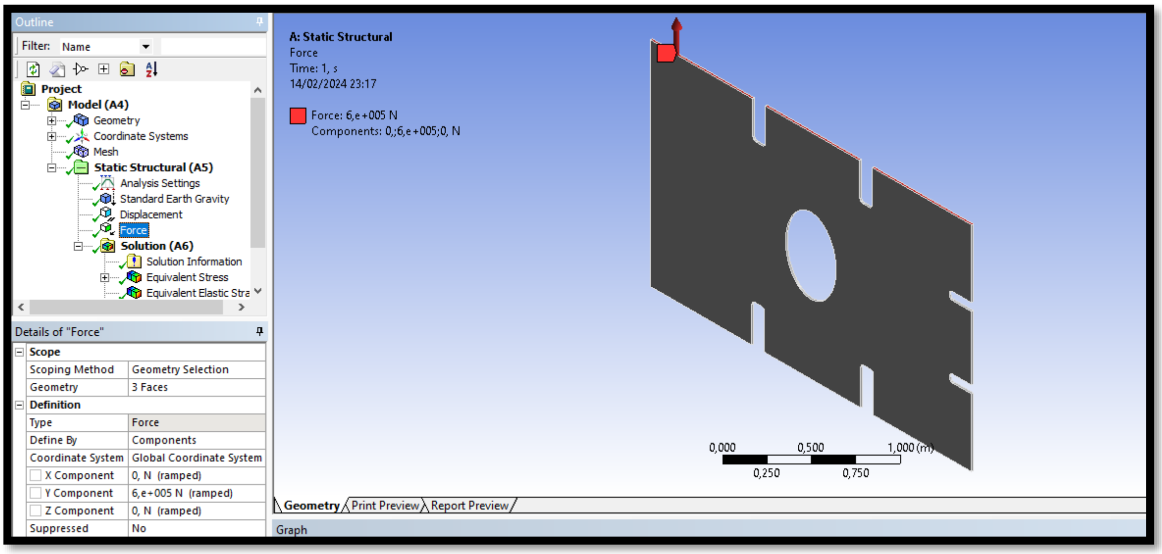


Figure 12 Load applied

Test: stress (Von Misses) prior convergence analysis.

Values [Table 5] of stress status [Figure 13] in transverse plate floor model are obtained, analyzed it under the boundary conditions considered and with the established loads.

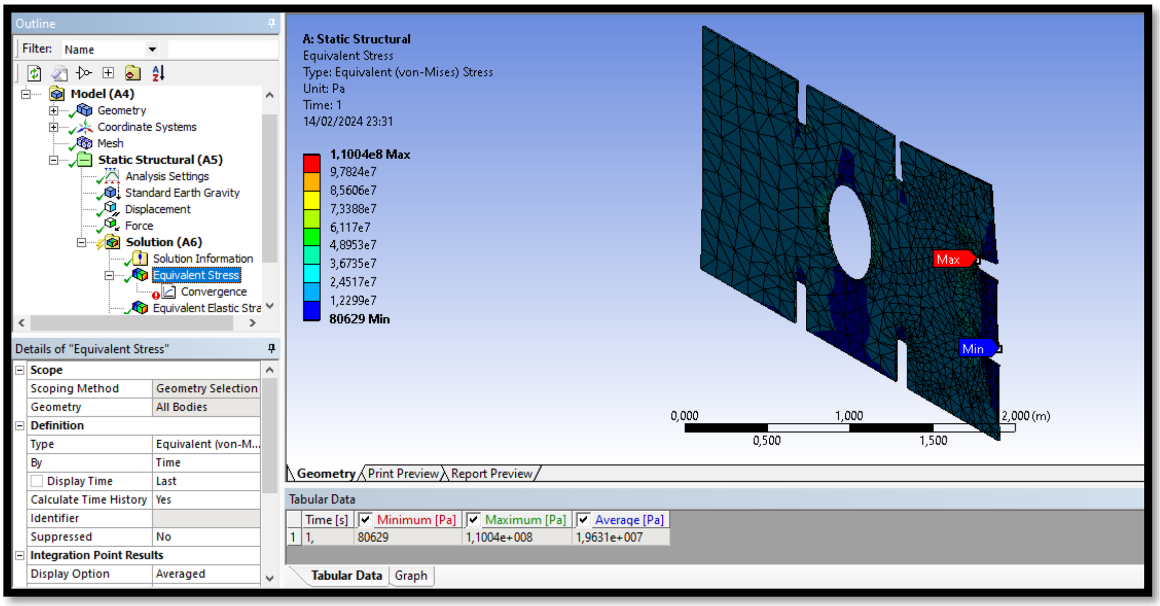


Figure 13 Stress

Minimum value (Pa)	Maximum value (Pa)	Average value (Pa)
80629	1,1004e+08	1,9631e+07

Table 5 Stress values

Convergence analysis.

The process of convergence consists of ensuring that the meshing of a body allows the solutions obtained from it be as close as possible to reality.

It is an iterative process.

A) A mesh by default is established.
B) Boundary conditions are established.
C) Applied loads is established.
D) It is performed stress analysis and obtain the average value of the stress.
E) The initial mesh is refined, at those points where from the previous analysis is detected higher values of the stress, it is necessary to increase the number of nodes and consequently increase the number of objects.
F) On this new mesh, stress analysis is repeated and obtained average value. This process is repeated until the difference between the last and previous value is between 5% and 10%.
G) "ansys" program has the option to perform this process automatically.

Initial mesh has 2839 nodes, and 347 elements.

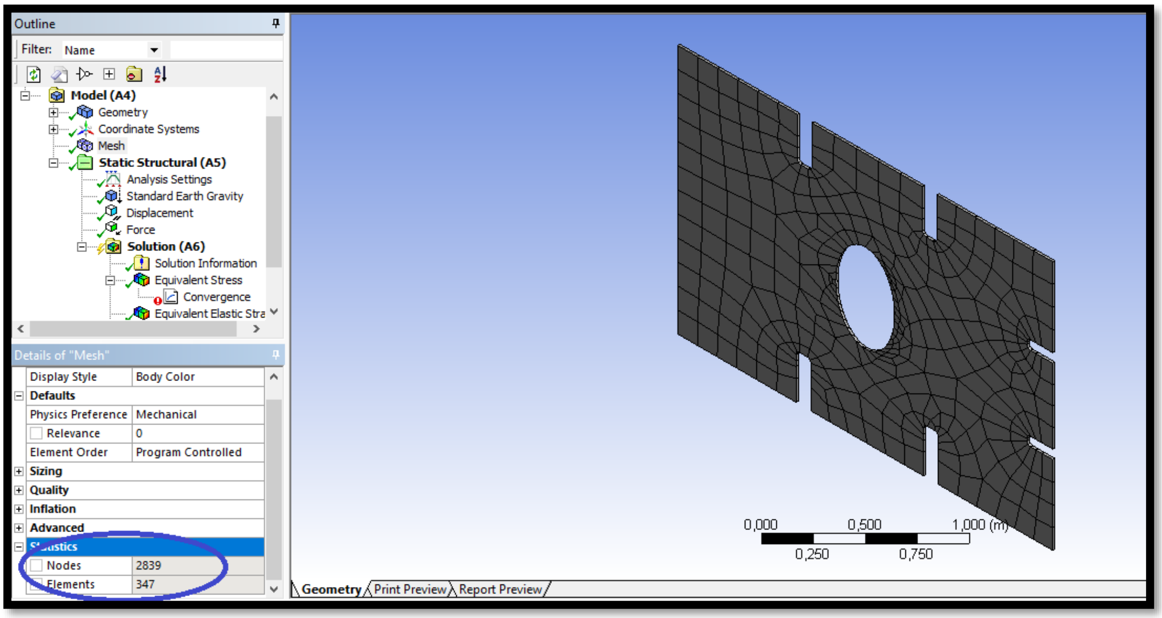


Figure 14 Convergence analysis

Convergence analysis [Figure 14] is performed with the aim of obtaining a more accurate mesh that the original one.

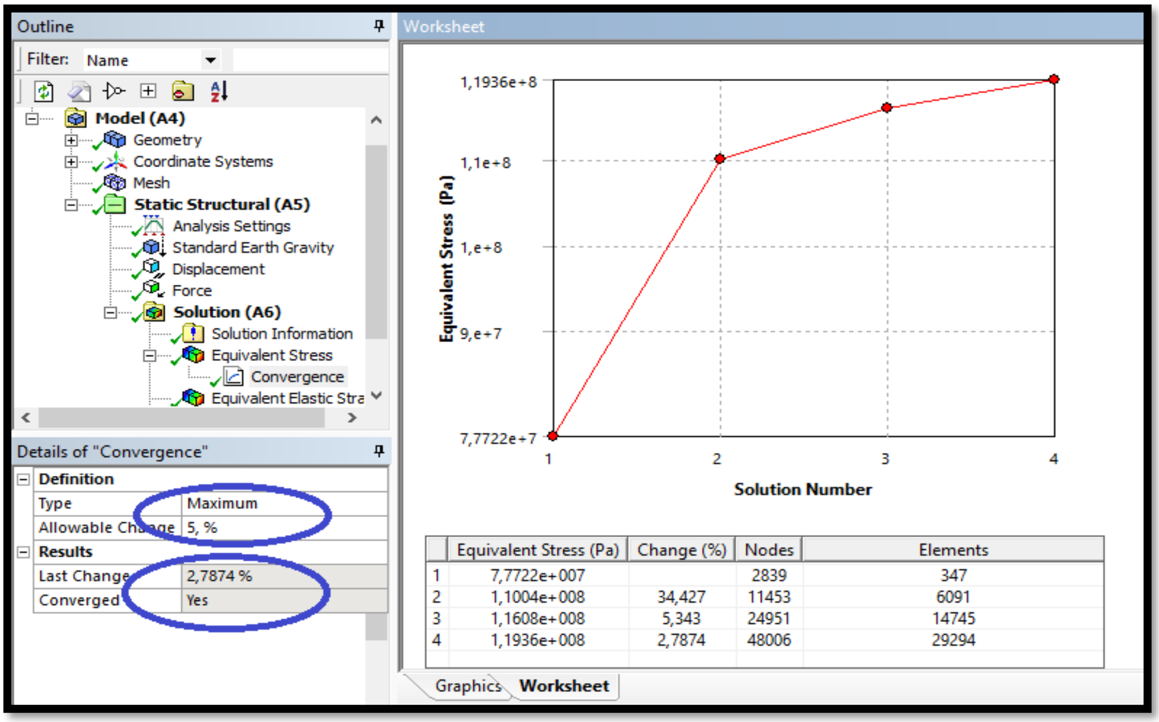


Figure 15 Convergence analysis result

It is necessary a total of 2 iterations, until a refined mesh that makes the difference in stress between the last iteration and the penultimate iteration less than 5%.

In this way, it is obtained a mesh that is different from the initial one which is more refined and complies with the provisions of a mesh convergence criterion.

This mesh has 40086 nodes and 29294 elements (the initial 2839 nodes, 347 elements) [Figure 15].

Test, stress (Von Misses).

Stresses values [Table 6] [Figure 16] of the transverse plate floor analyzed under the boundary conditions considered, with the established loads and with the meshing obtained after the convergence analysis are obtained.

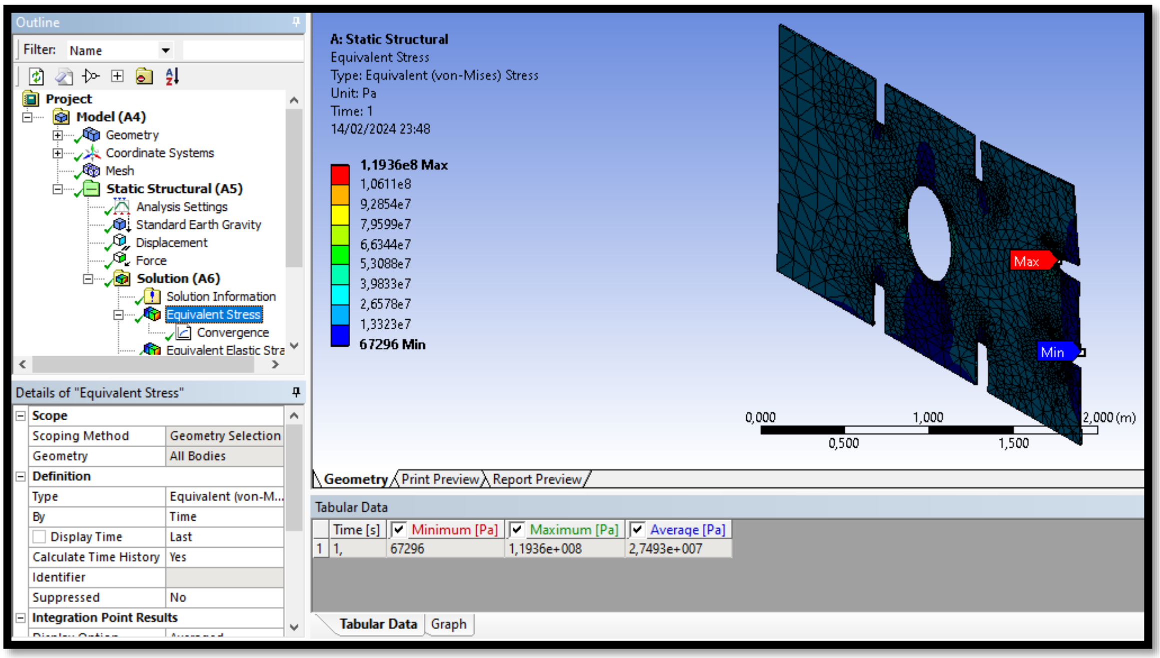


Figure 16 Stress

Minimum value (pa)	Maximum value (pa)	Average value (pa)
67296	1,1936e+08	2,7493e+07

Table 6 Stress values

Test, strain (Von Misses).

Strain values [Table 7] of the transverse plate floor analyzed has in the boundary conditions considered, with the established loads and with the meshing obtained after the contour analysis are obtained.

Minimum value (m/m)	Maximum value (m/m)	Average value (m/m)
1,4677e-06	5,9685e-04	1,3806e-04

Table 7 Strain values

Test, deformation.

Deformations values [Table 8] of the transverse plate floor analyzed has in the boundary conditions considered, with the established loads and with the meshing obtained after the contour analysis are obtained.

Minimum value (m)	Maximum value (m)	Average value (m)
0,0	2,4829e-04	9,6153e-05

Table 8 Deformation values

Fatigue.

Fatigue appears under loads act on a material in a cyclical manner.

Fatigue. Cyclic loads on a material: medium stress, minimum stress and maximum stress.

There are different stress concepts [Figure 17] to bear in mind in fatigue test.

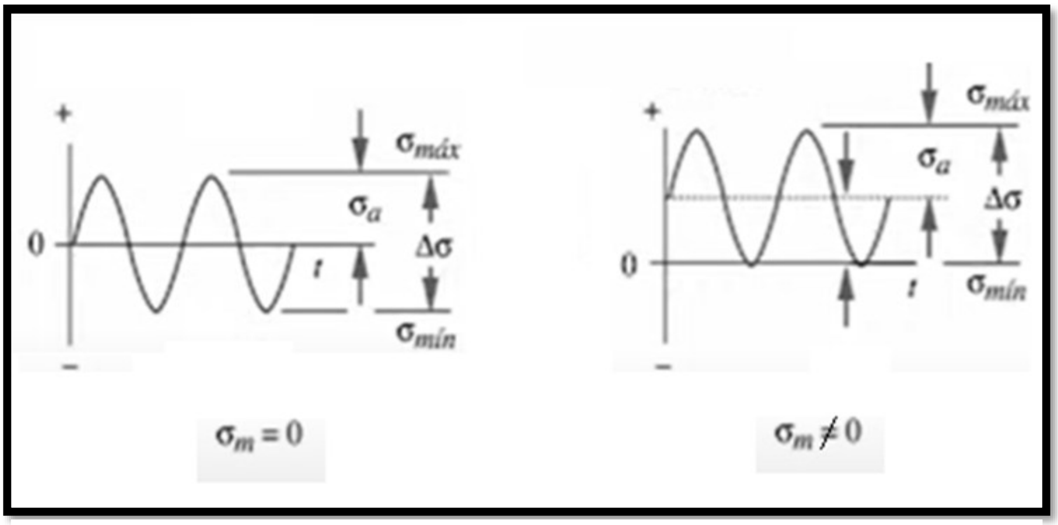


Figure 17 Stress in fatigue

$$\boldsymbol{\sigma_m}: average\ stress = \frac{\sigma_{máx} - \sigma_{min}}{2}$$

$$\boldsymbol{\sigma_{max}}: maximum\ value\ in\ stress\ cycle$$

$$\boldsymbol{\sigma_{min}}: minimum\ value\ in\ stress\ cycle$$

$$\boldsymbol{\sigma_m}: average\ stress\ may\ be\ not\ zero$$

Fatigue. S_N curves: stress and number of cycles.

This curve shows the number of cycles that a material can withstand when a stress is applied.

These curves are different in each material and are obtained empirically.

The process is based on::

- A material is established.
- A stress σ_a is selected .
- This stress is applied to the material reversibly, $\sigma_m = 0$. In other words, the applied stress range from σ_a to -σ_a
- These stresses are applied σ_a , -σ_a repeatedly until the material breaks.
- The process is repeated but with a different value σ_a.

If the material is stressed below the fatigue limit, the material would theoretically last an infinite number of cycles.

Fatigue. S_N curves: stress and number of cycles of different materials.

For each material, corresponding S_N curves are established depending on the stress applied σ_a($\sigma_m = 0$) and number of cycles.

Fatigue. S_N curves: not zero average stress $\sigma_m \neq 0$.

When stress $\sigma_a$is not applied in reversibly way ($\sigma_m \neq 0$) correction criteria needs to be applied.

Fatigue test.

Number of cycles before fracture values of the transverse plate floor analyzed has in the boundary conditions considered, with the established loads and with the meshing obtained after the contour analysis are obtained.

Ratio value is obtained with maximum and minimum stress and it is established, [Figure 18].

Maximum shear stress (+): 57500 KN -> Maximum stress (+): 46 Mpa

Maximum shear stress (-): -38500 KN -> Maximum stress (-): -31 Mpa

$\sigma_m \neq 0$.

Ratio value $\frac{\sigma_{m(+)}}{\sigma_{m(-)}} = \frac{46}{-31} = -1{,}48$

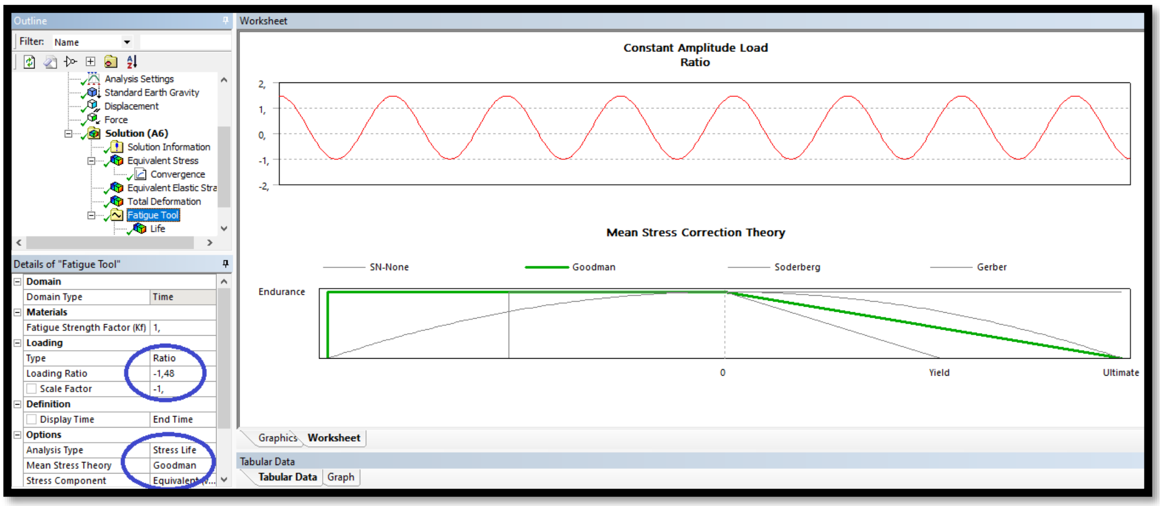


Figure 18 Fatigue test ratio value

Values of number of cycles [Table 9] before fracture of the transverse plate floor model, analyzed it under the boundary conditions considered and with the established loads in fatigue test are obtained.

Minimum value (nº cycles)	**Maximum value (nº cycles)**	**Average value (nº cycles)**
77341	1,e+06	9,7039e+05

Table 9 Number of cycles in fatigue test

4.3.2.Numeric simulations. Response under bending moment.

As shear forces test, it is developed test under bending moment situation.

The process is equal to the previous one except regarding loads type applied.

In order to subsequently carry out a laboratory test, it is applied a force that can be emulated in the subsequent test.

Load= 4,5 KN (0,0,1)

Achieved results.

Stress, strain, deformation and fatigue life of the 72 transverse plate floor are obtained.

All results are attached in [Annex II.].

5 RESULTS DISCUSSION

The study aims to obtain the response to shear stress and bending moment scenarios in a set of sections and transverse plate floor differents to the original one and permissible by the regulatory framework of classification societies. In each of these scenarios it is obtained stress, strain, deformation and fatigue life values.

As results discussion it is compared the original one plate and plate wich the best porperties in every scenario.

5.1. Shear stress scenario.

According to [Graph 1] it is observed that in the comparison between plate nº 52 [Figure] and the original plate nº 4[Figure 19] the first one shows favorable values. In relation to stress, the aim is to ensure that the value of the maximum tension is as low as possible, as well as the value of the average tension. In this comparison it is observed that the maximum stress value in nº 52 is 9,73+E07 Pa which is lower than 1,18+E08 Pa corresponding to nº 4, and a similar trend about average stress 1,88E+07 Pa and 2,00E+07 Pa respectively.

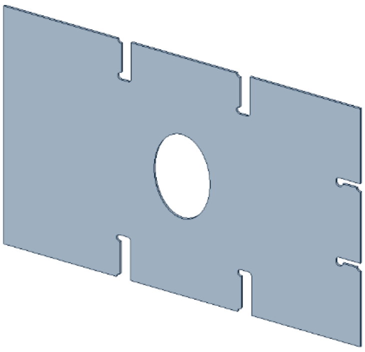


Figure 19 Plate nº4

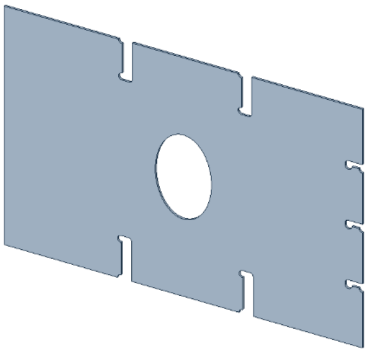


Figure 20 Plate nº52

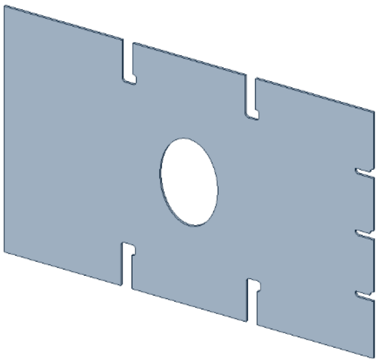
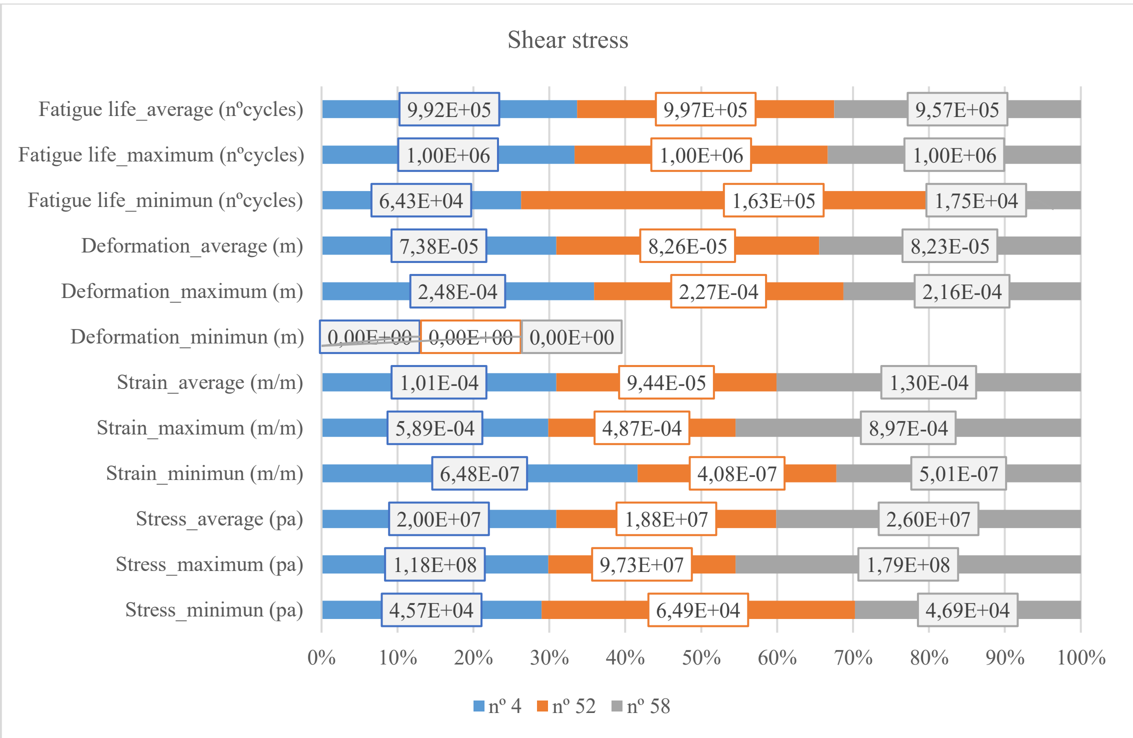


Figure 21 Plate nº58



Graph 1 Main results shear stress

In [Graph 1], it shows as well comparison between plates nº 58 [Figure 20] and nº 52 [Figure] with respect to the original plate nº 4 [Figure 19]. At this point deformation and fatigue life behaviors are compared respectively. In the first one maximum deformation is sought to be as low as possible, observing that plate nº 58 shows a deformation of 2,16E-04 m lower than the 2,48E-04 of the original plate nº 4. Regarding the fatigue life minimum number of cycles before the limit is sought to be as high as possible, observing that in plate nº 52 number of cycles is 1,63E+05 while in the original plate this number is 6,43E+04.

5.2. Bending moment scenario.

As in previous scenario according to the [Graph 2], it is observed that plate nº 1 [Figure 24] has better values compared to plate nº 4 [Figure 23]. In relation to stress as previously indicated, the objective is that maximum stress and average stress value to be as low as possible. Plate nº 1 shows a maximum stress and average stress respectively of 1,57E+08 Pa and 3,15E+07 Pa which are lower than plate nº 4, 1,84E+08 Pa and 3,38E+07 Pa.

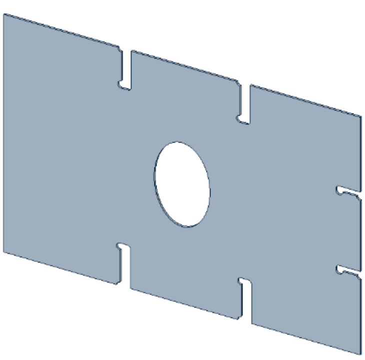


Figure 21 Plate nº4

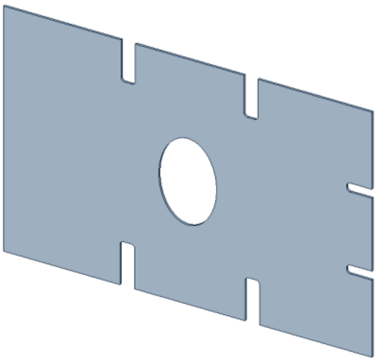


Figure 22 Plate nº1

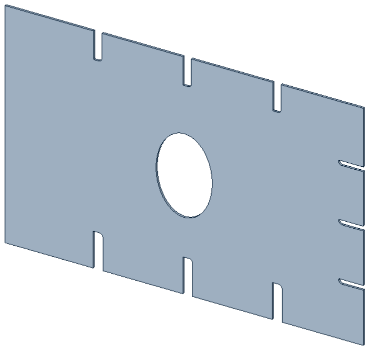
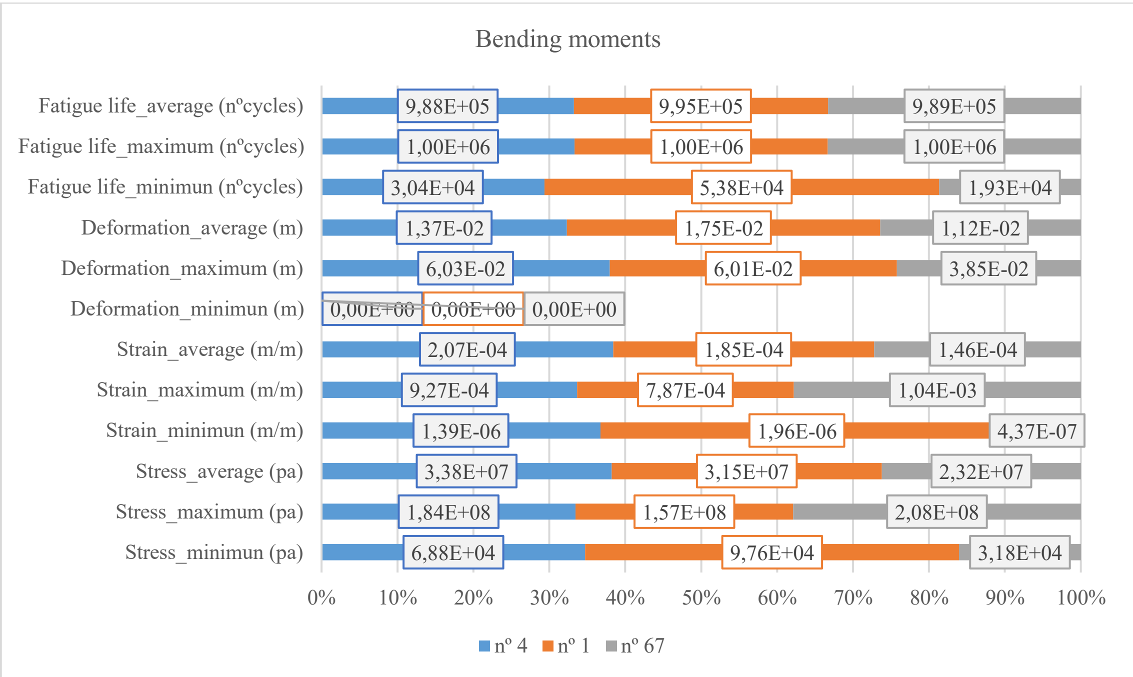


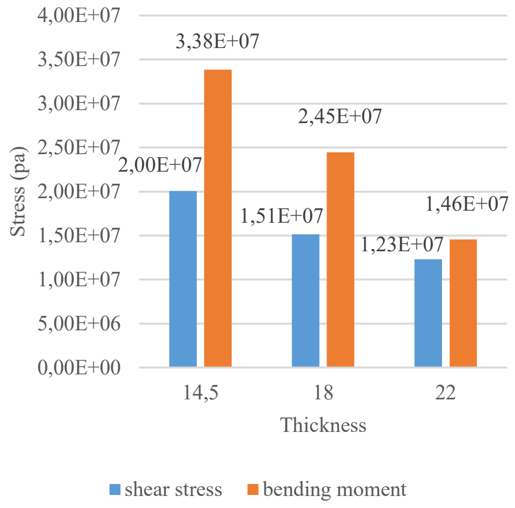
Figure 20 Plate nº67



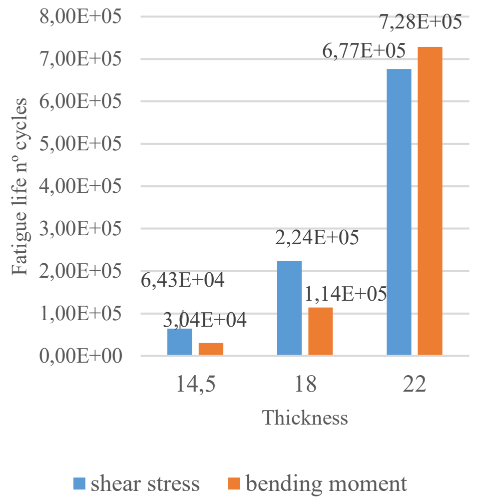
Graph 2 Main results bending moments

Regarding deformation and fatigue life, according to [Graph 2] it is observed that plates nº1 [Figure 24] and nº 67 [Figure 22] show favorable values compared to plate nº4 [Figure 23]. In this way average deformation in plate nº 67 is 1,12-E02 m lower than 1,37-E02 corresponding to plate nº4, while minimum number of cycles in plate nº1 is 5,38+E04 which is greater than 3,04+E04 of original one plate nº4.

Respect to an increase in thickness, stress [Graph] in shear stress and bending moment scenario of the original one transverse plate decreases by 25%, 39% and 28%, 57%, respectively, while the number of cycles [Graph] in the fatigue life increases in the shear and bending scenarios, respectively 349%, 1052% and 376%, 2395%.



Graph 3 Average stress and thickness



Graph 4 Average fatigue life and thickness

Although it is not the main objective of the study, it is observed that as expected, an increase in thickness generates an improvement in the structural properties, but it would be advisable to link a specific study of the increase in thickness with the increase in weight of the assembly.

As results discussion only values between the original one and the alternative that presents the best values for each property have been compared.

6 CONCLUSION

The main objective of the study is to obtain and analyze the structural properties of a set of alternative transverse plates designs in Panamax container ships. In this way, if there are designs with better structural properties, they could be positive alternatives in container ships design.

Along process a set of alternative sections and plates have been obtained in accordance with the regulatory framework of institutions and classification societies. Subsequently structural properties of designs have been analyzed in different scenarios and finally compared with original plate obtaining favorable properties in some of the alternative designs, so the main study objective could be considered as favorable.

Although in results discussion only have been analyzed the best plate in every scenario, there are other alternatives which shown favorable properties than the original one plate. About this it is possible to affirm that the results obtained show a set of alternative arrangements being able to present themselves as possible variants and help in the design of this type of ships.

About possible future studies, this one has as weakness of being only focused on transverse plate floors. It could be desirable to study the set of plates and the section that composes it as a joint structure: bottom, double bottom, side girders, longitudinal and transverse plate floor.

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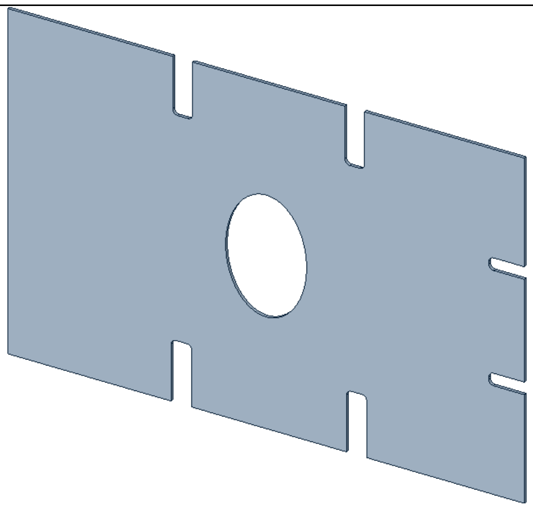
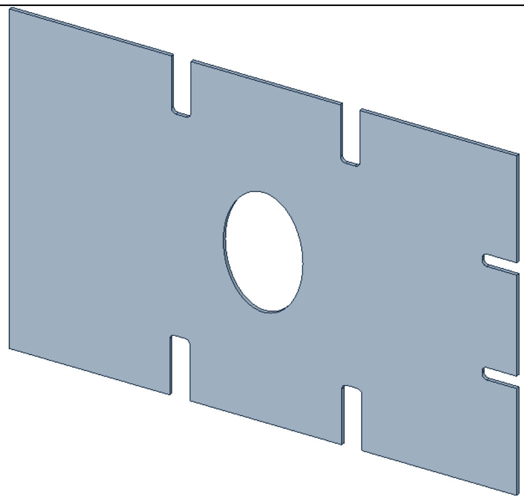
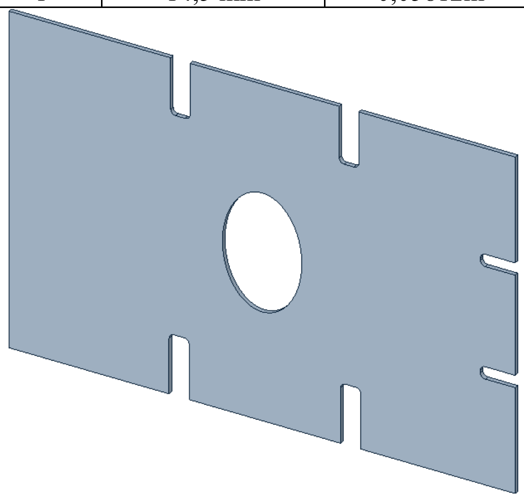
Annex I.



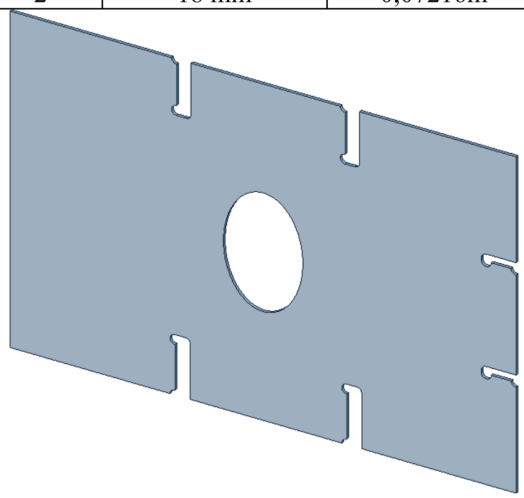
Nºplate	Thickness	Volume
1	14,5 mm	0,05812m³



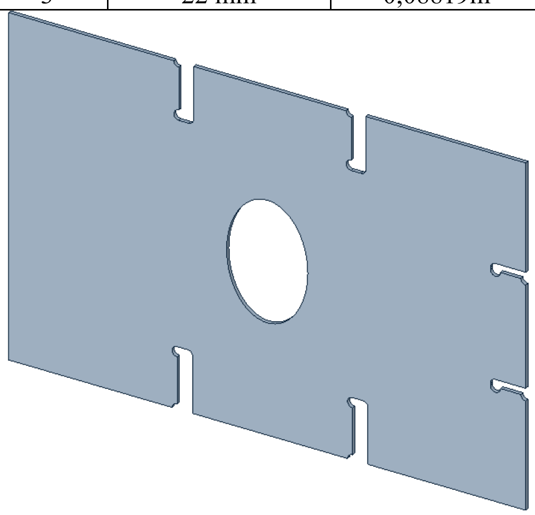
Nºplate	Thickness	Volume
2	18 mm	0,07216m³



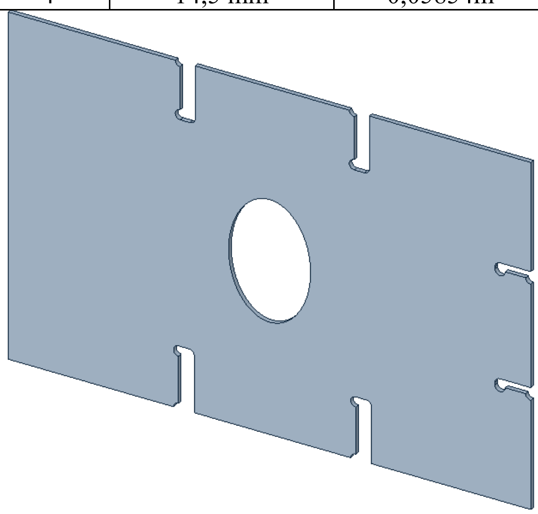
Nºplate	Thickness	Volume
3	22 mm	0,08819m³



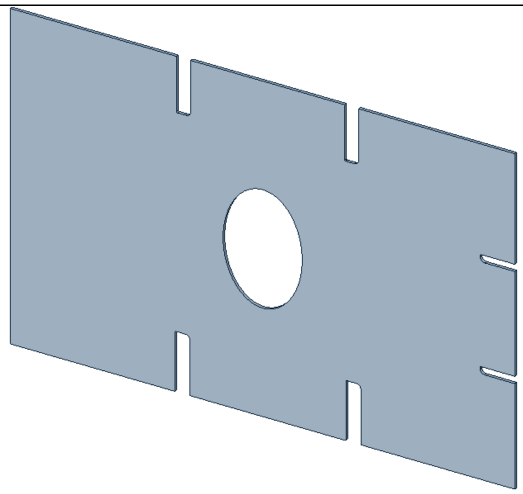
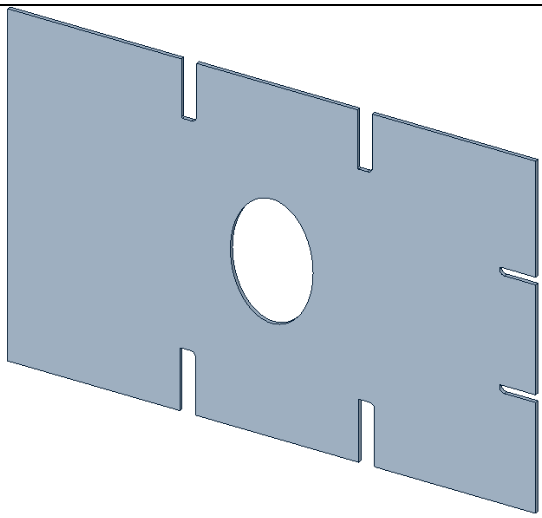
Nºplate	Thickness	Volume
4	14,5 mm	0,05854m³



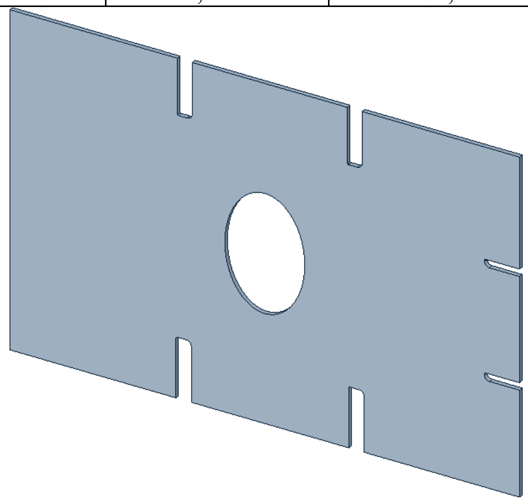
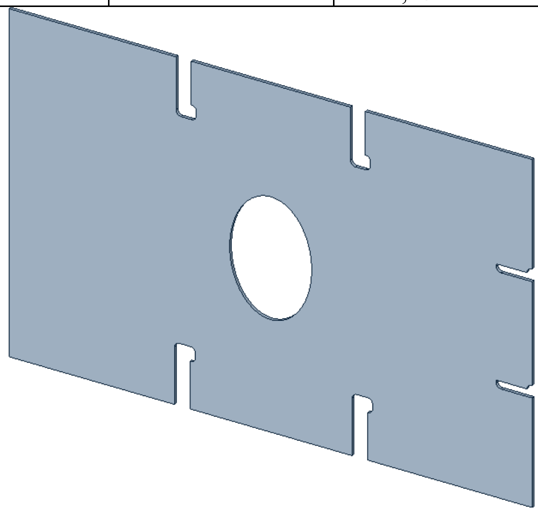
Nºplate	Thickness	Volume
5	18 mm	0,07267m³



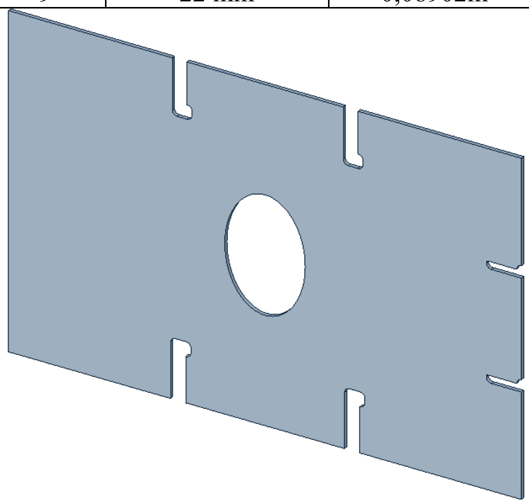
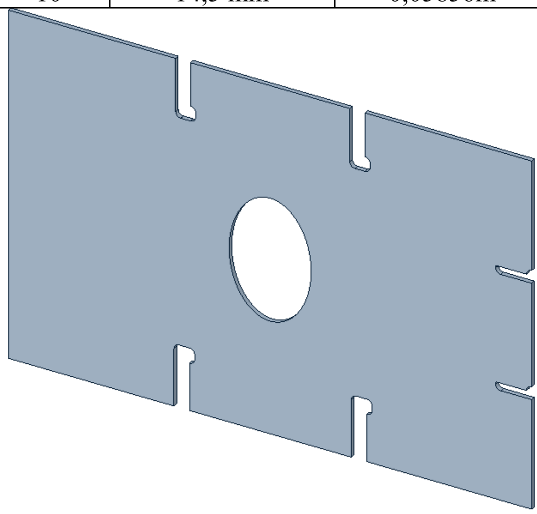
Nºplate	Thickness	Volume
6	22 mm	0,08882m³

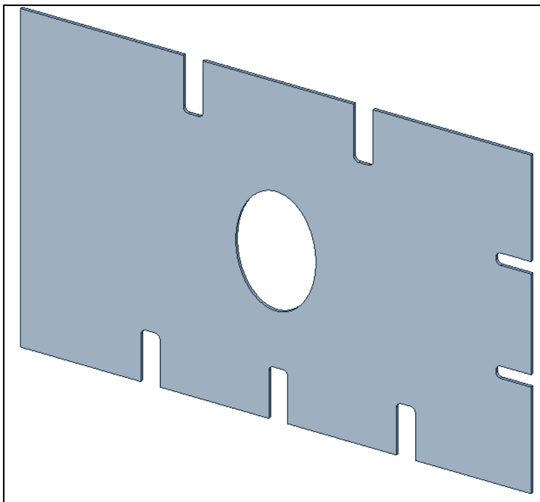
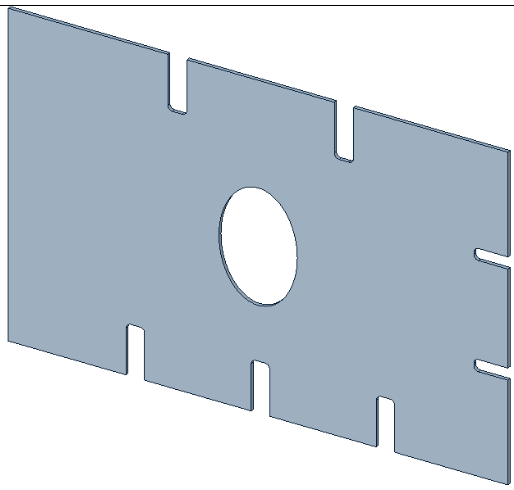
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
7	14,5 mm	58670,0m³	8	18 mm	0,07283m³

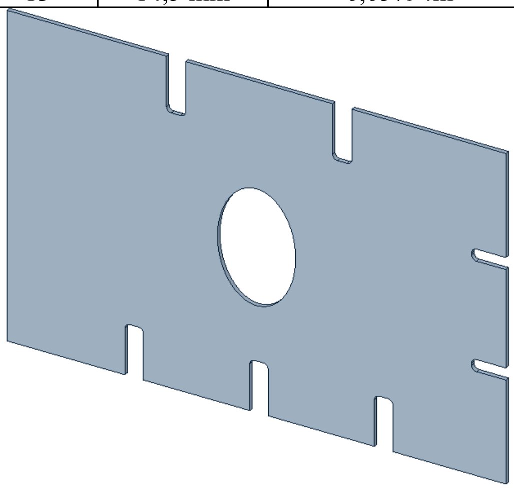
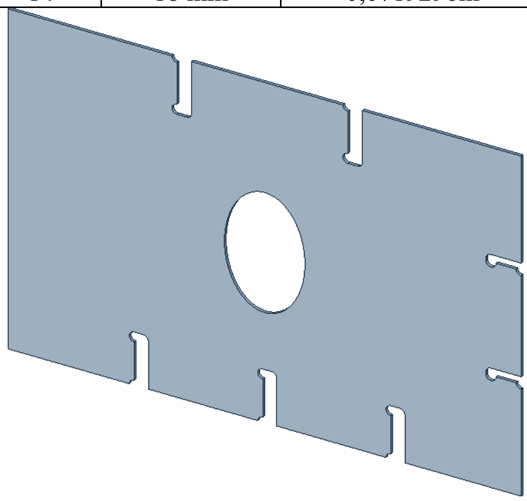
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
9	22 mm	0,08902m³	10	14,5 mm	0,05856m³

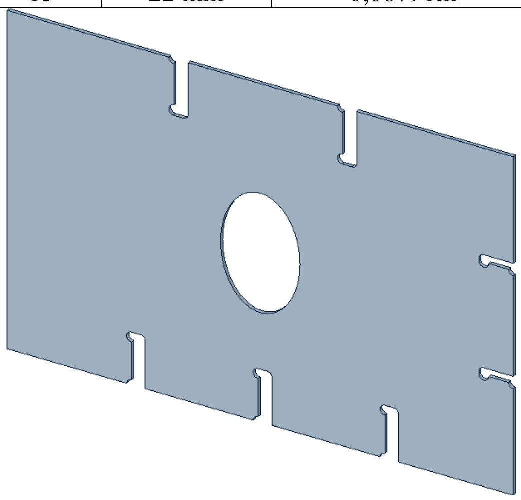
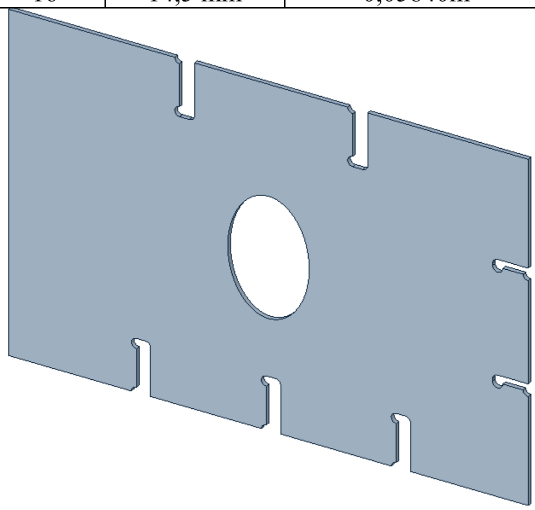
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
11	18 mm	0,07270m³	12	22 mm	0,08886m³

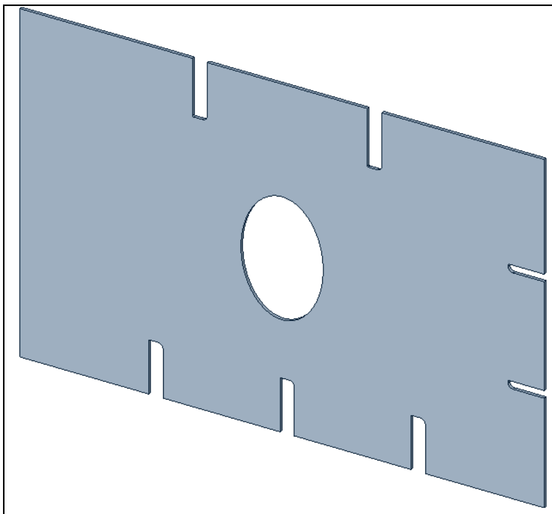
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
13	14,5 mm	0,05794m³	14	18 mm	0,0719296m³

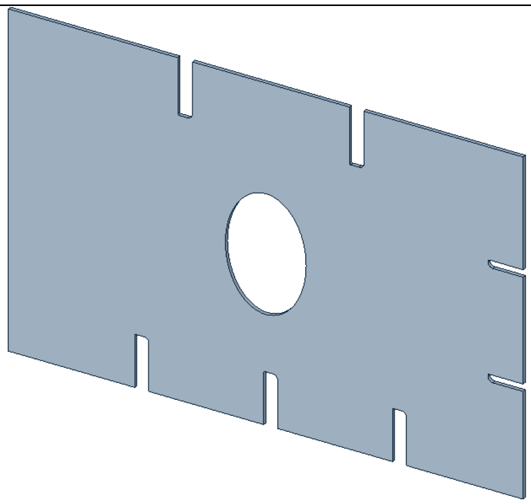



Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
15	22 mm	0,08791m³	16	14,5 mm	0,05840m³

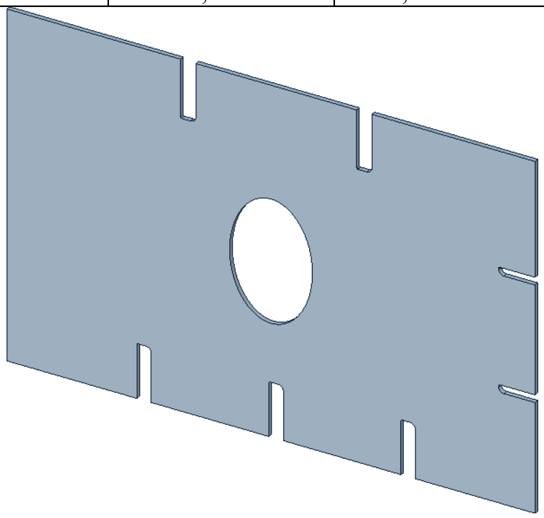



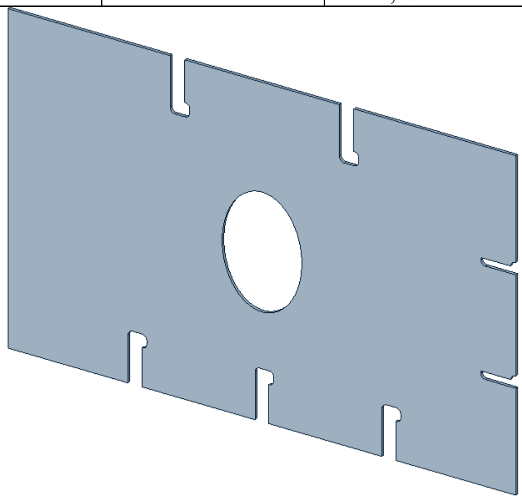
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
17	18 mm	0,07249m³	18	22 mm	0,08860m³



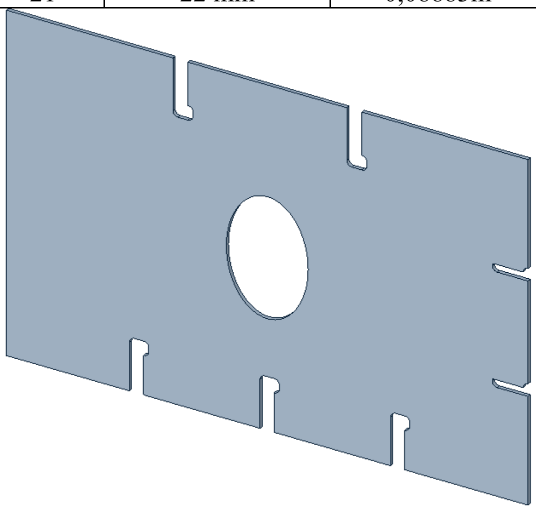


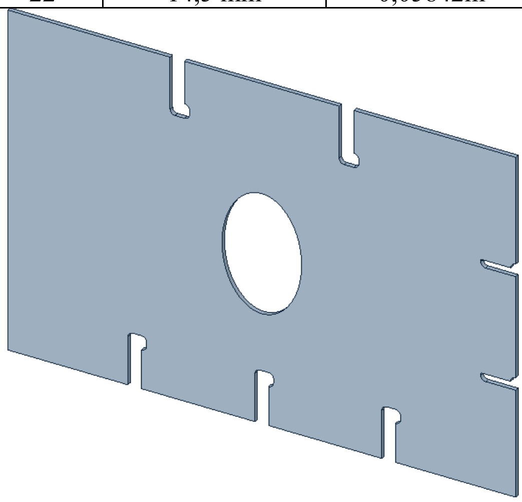
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
19	14,5 mm	0,05855m^3	20	18 mm	0,07268m^3



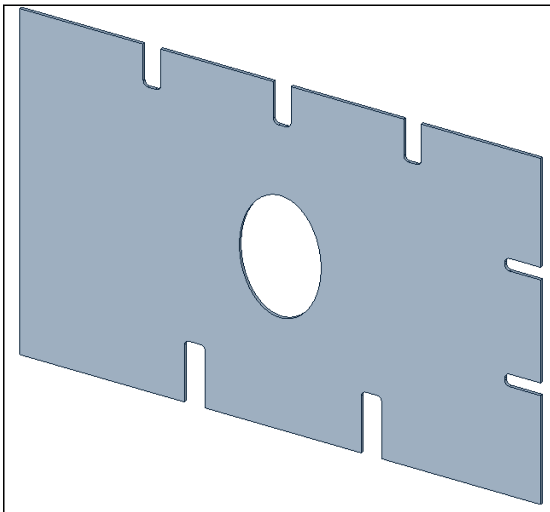


Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
21	22 mm	0,08883m^3	22	14,5 mm	0,05842m^3

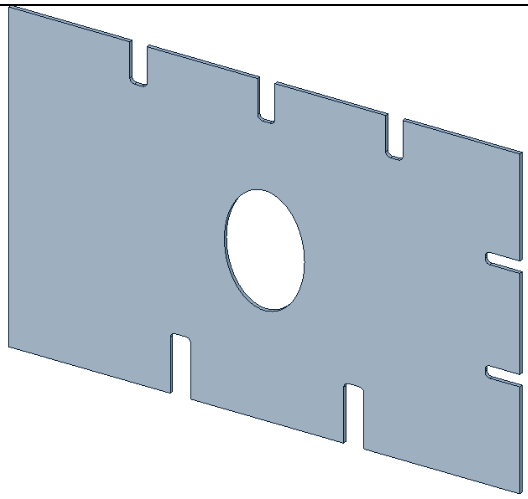




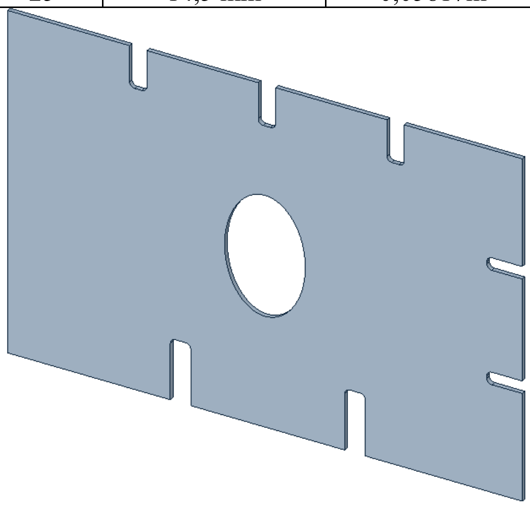
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
23	18 mm	0,07253m^3	24	22 mm	0,08865m^3



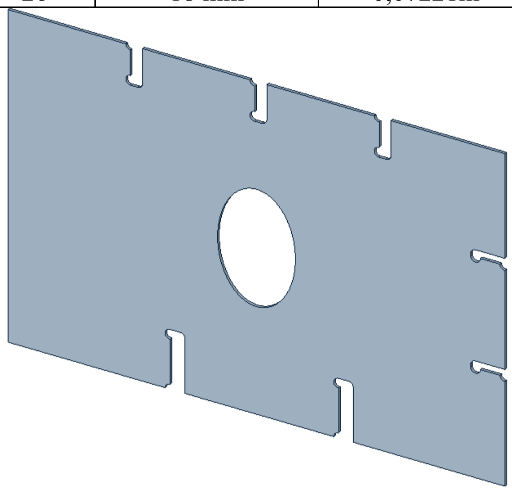
Nºplate	Thickness	Volume
25	14,5 mm	0,05817m³



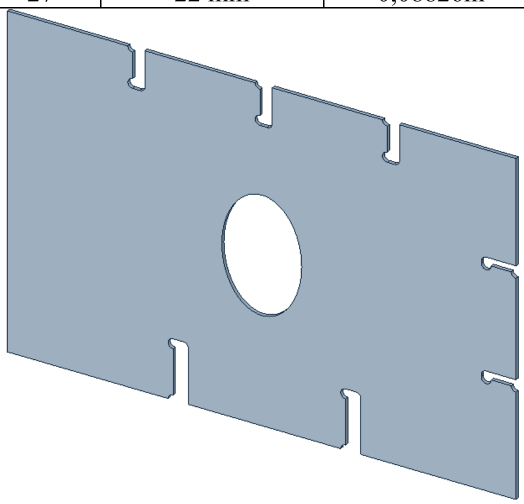
Nºplate	Thickness	Volume
26	18 mm	0,07221m³



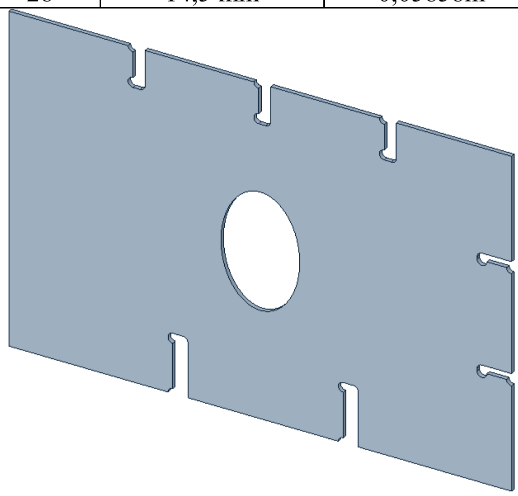
Nºplate	Thickness	Volume
27	22 mm	0,08826m³



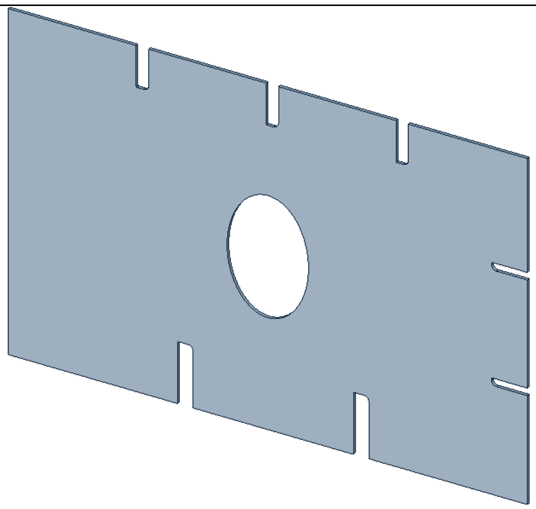
Nºplate	Thickness	Volume
28	14,5 mm	0,05858m³

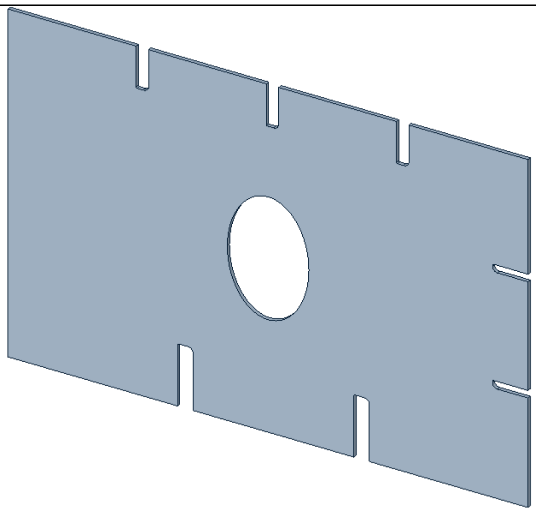


Nºplate	Thickness	Volume
29	18 mm	0,07272m³

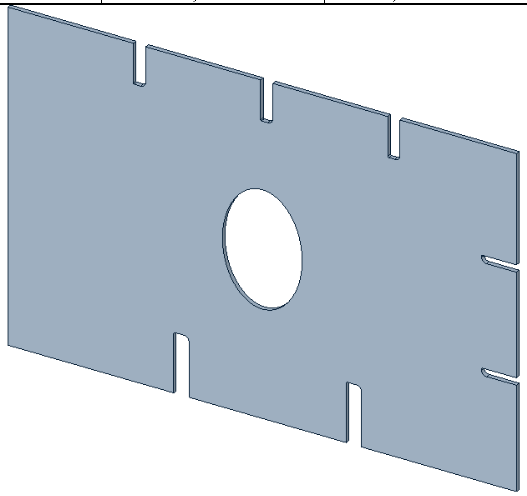


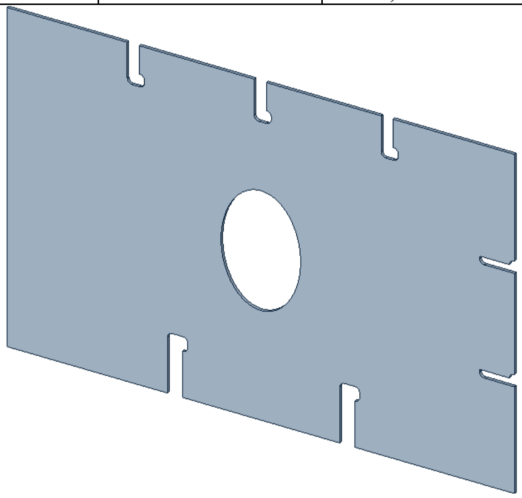
Nºplate	Thickness	Volume
30	22 mm	0,08888m³



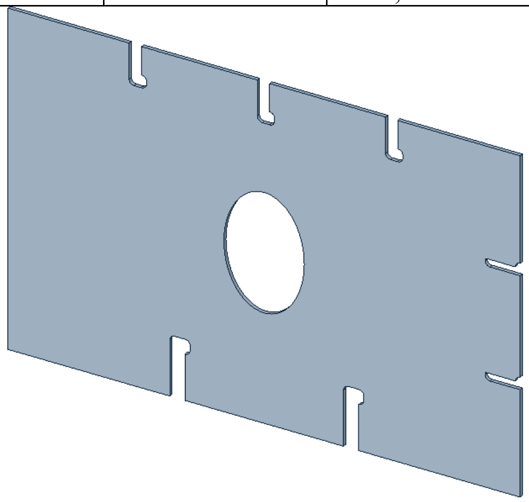


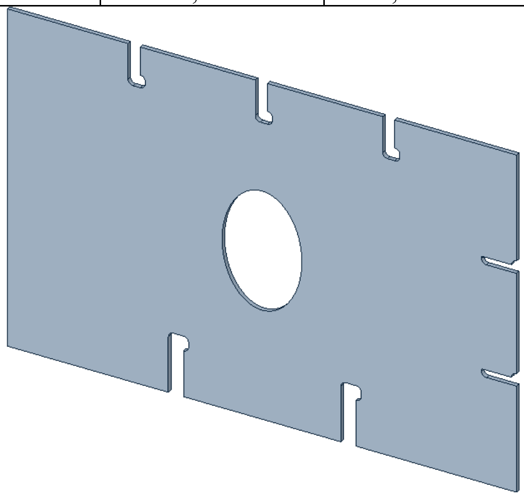
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
31	14,5 mm	0,05873m^3	32	18 mm	0,07291m^3



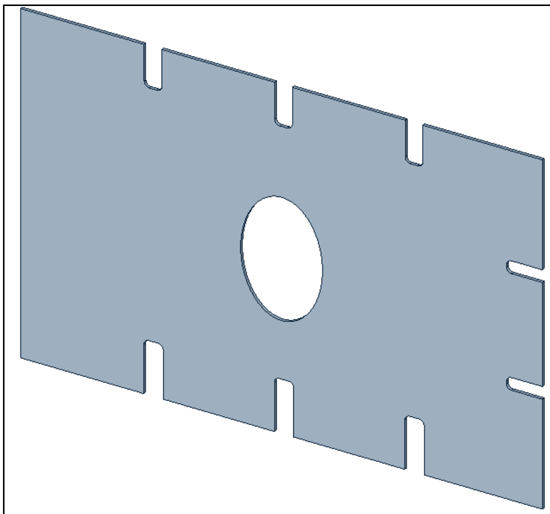


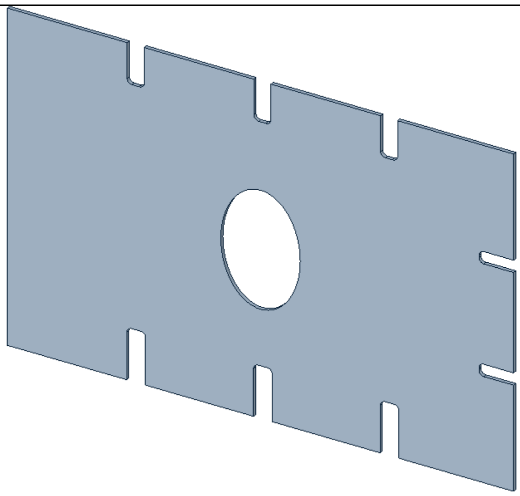
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
33	22 mm	0,08911m^3	34	14,5 mm	0,05861m^3



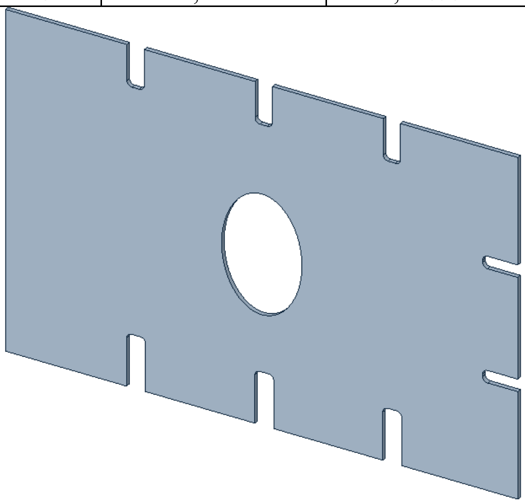


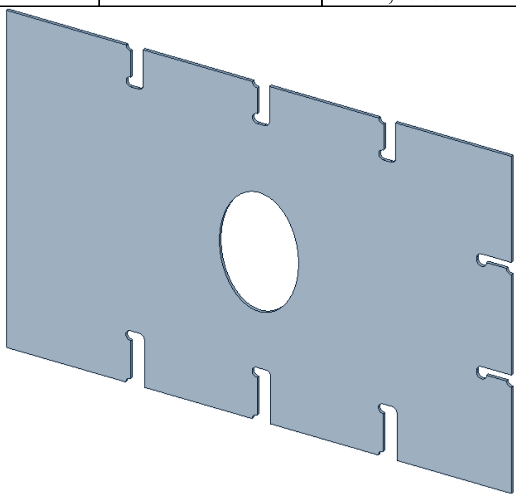
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
35	18 mm	0,07276m^3	36	22 mm	0,08893m^3



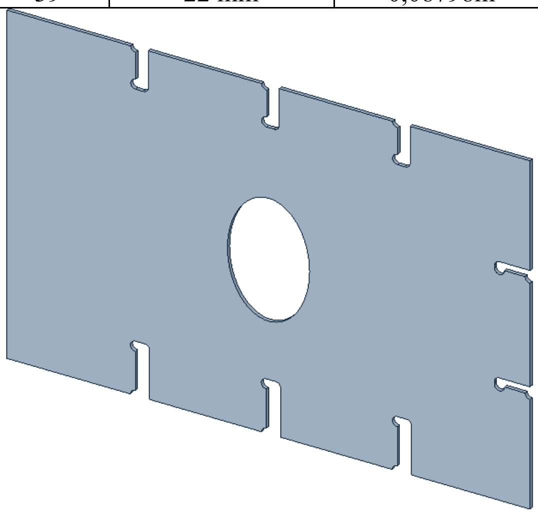


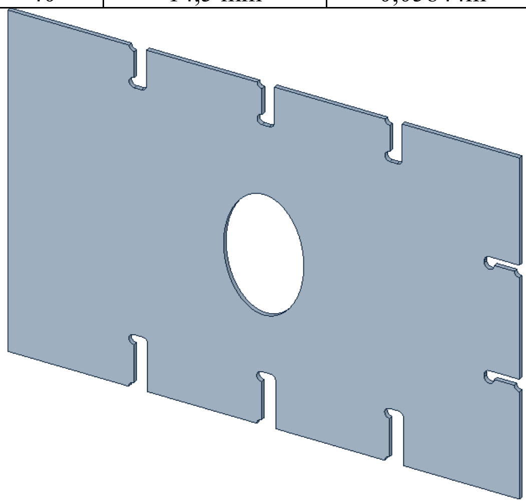
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
37	14,5 mm	0,05799m³	38	18 mm	0,07198m³



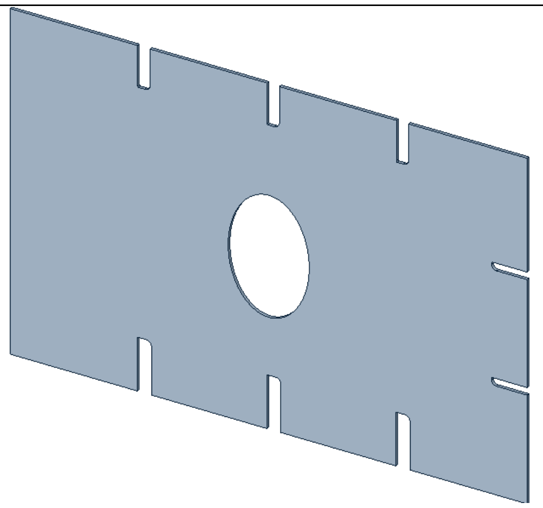
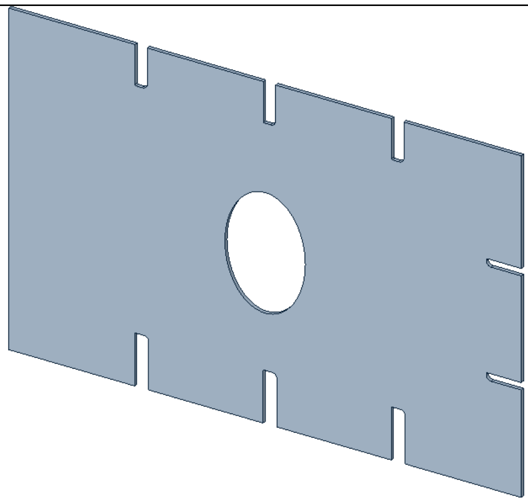


Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
39	22 mm	0,08798m³	40	14,5 mm	0,05844m³

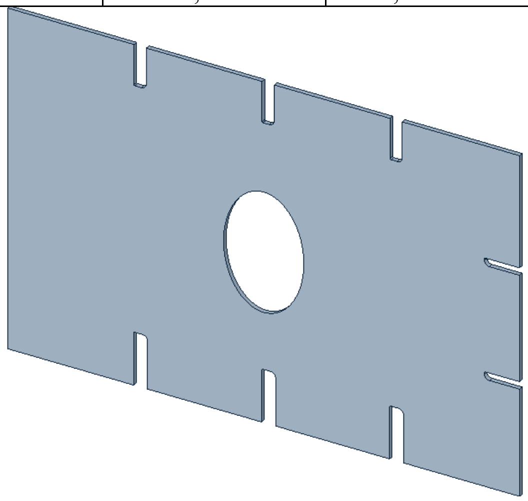
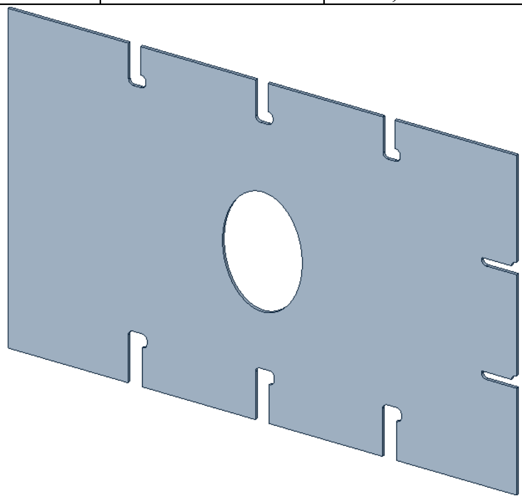




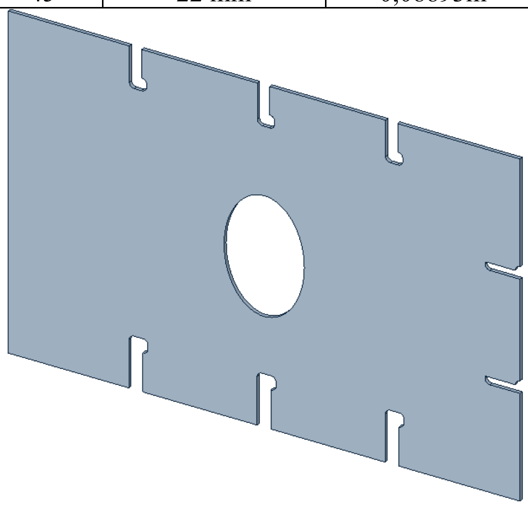
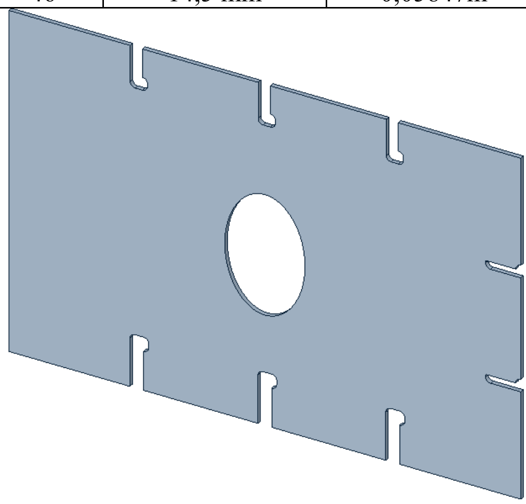
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
41	18 mm	0,07254m³	42	22 mm	0,08867m³

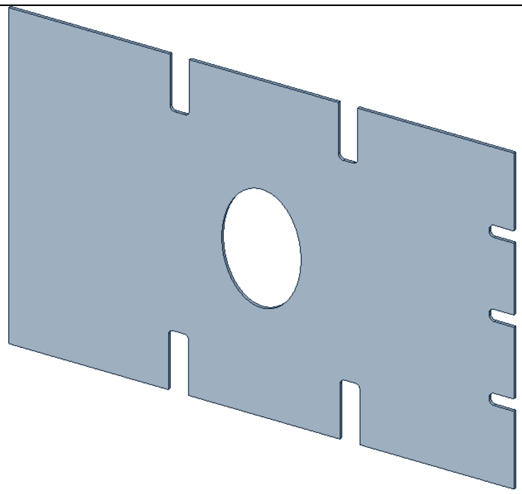
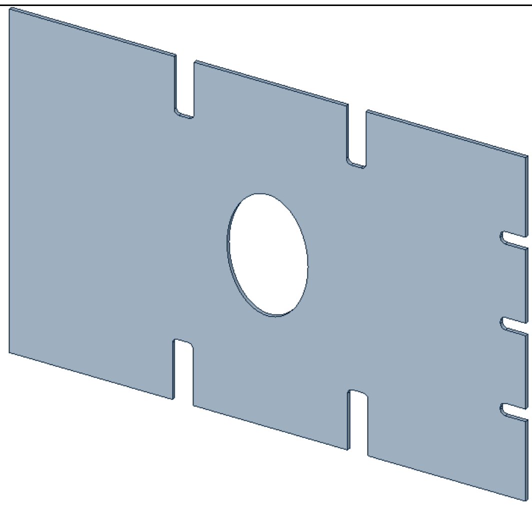
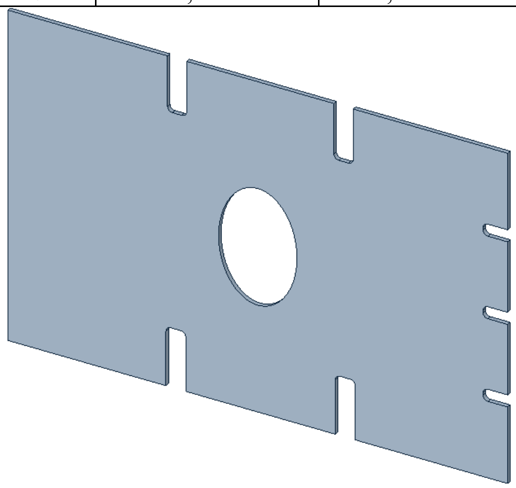
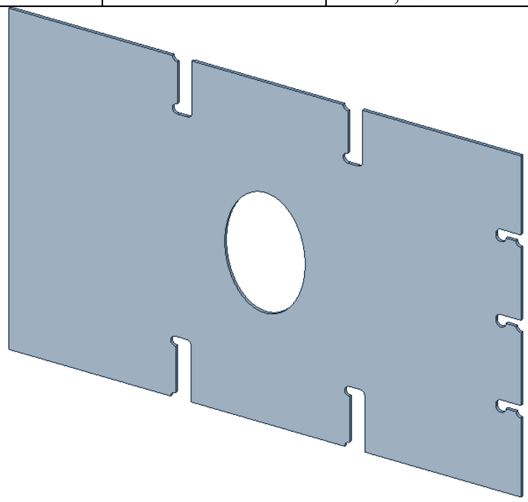
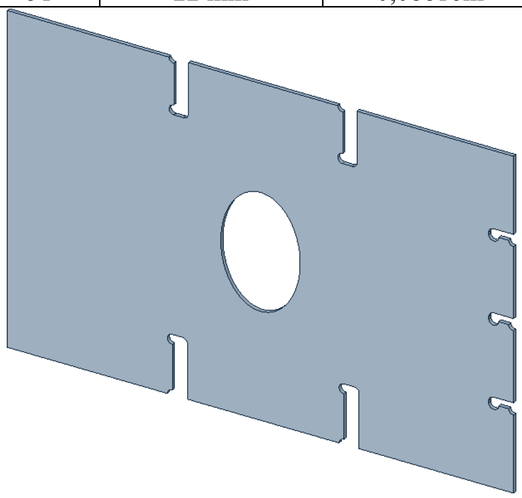
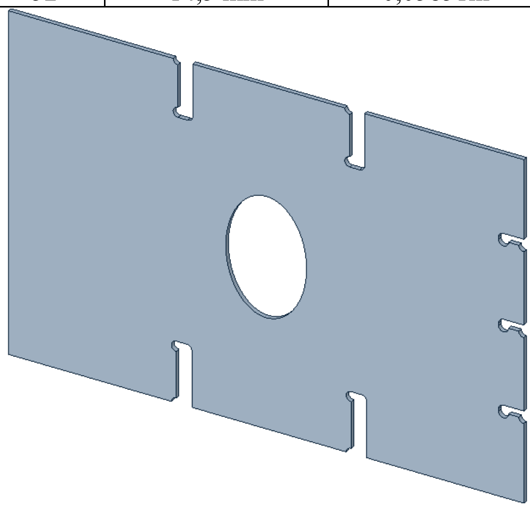
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
43	14,5 mm	0,05861m^3	44	18 mm	0,07276m^3

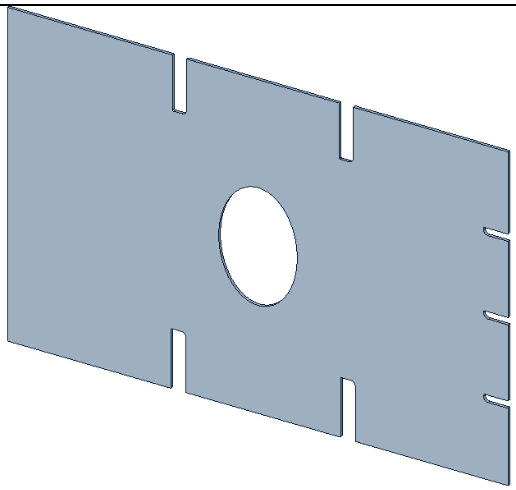
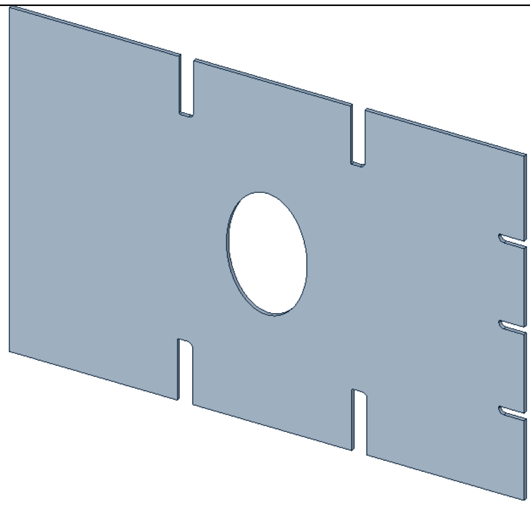
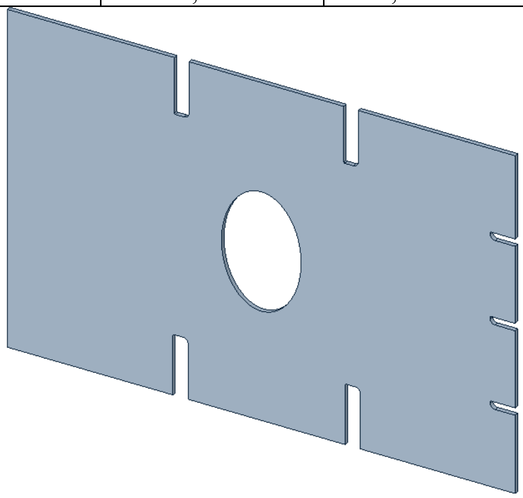
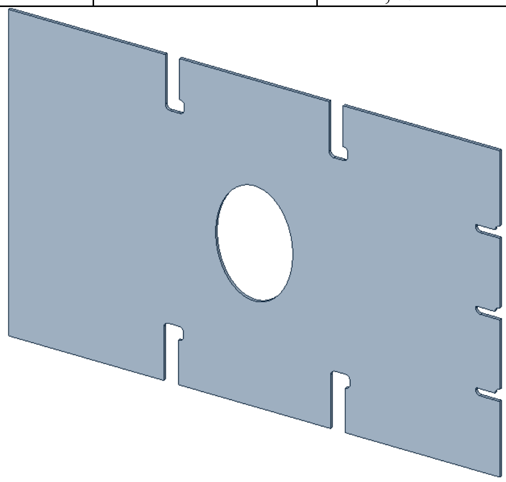
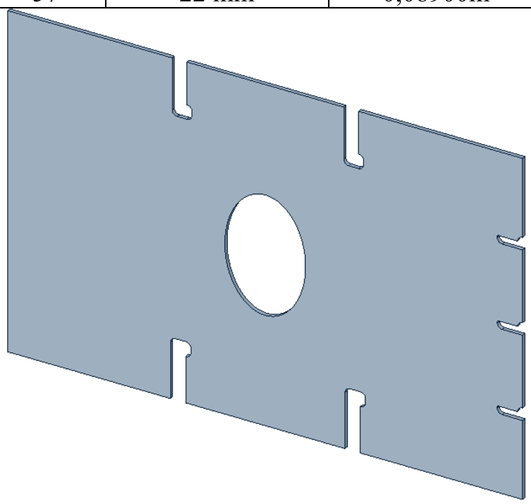
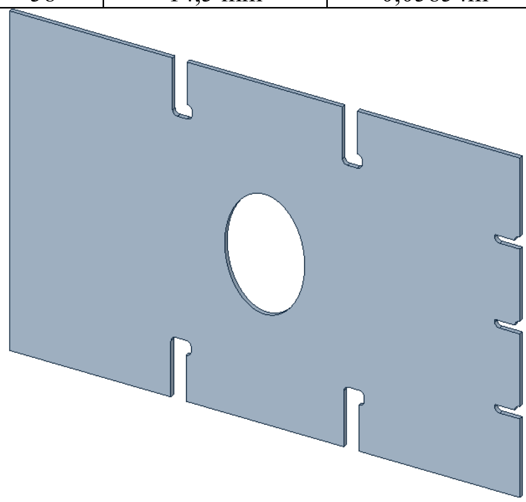



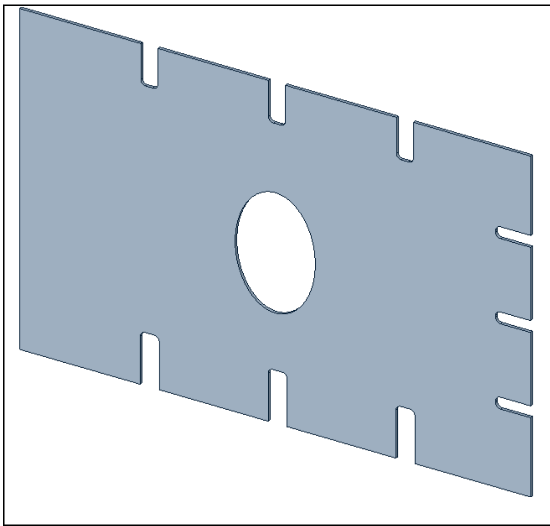
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
45	22 mm	0,08893m^3	46	14,5 mm	0,05847m^3

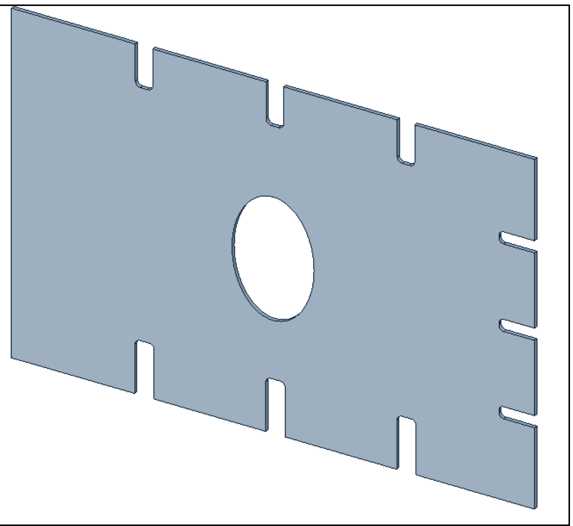



Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
47	18 mm	0,07259m^3	48	22 mm	0,08872m^3

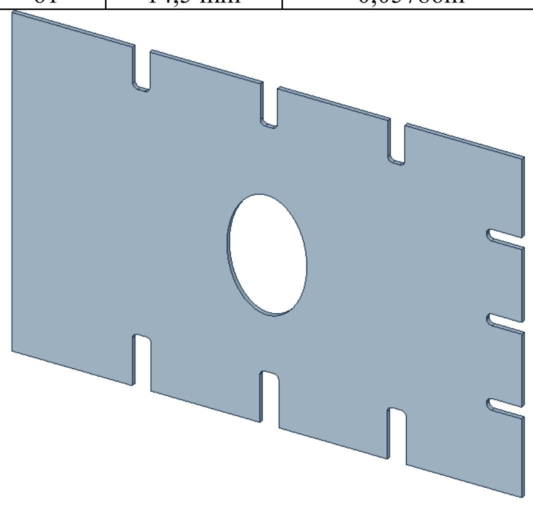
					
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
49	14,5 mm	0,05811m³	50	18 mm	0,07213m³
					
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
51	22 mm	0,08816m³	52	14,5 mm	0,05851m³
					
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
53	18 mm	0,07667m³	54	22 mm	0,08877m³

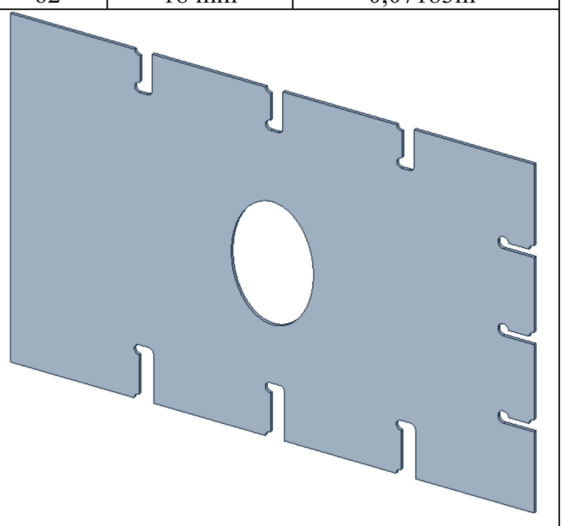
					
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
55	14,5 mm	0,05866m³	56	18 mm	0,07686m³
					
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
57	22 mm	0,08900m³	58	14,5 mm	0,05854m³
					
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
59	18 mm	0,07672m³	60	22 mm	0,08883m³



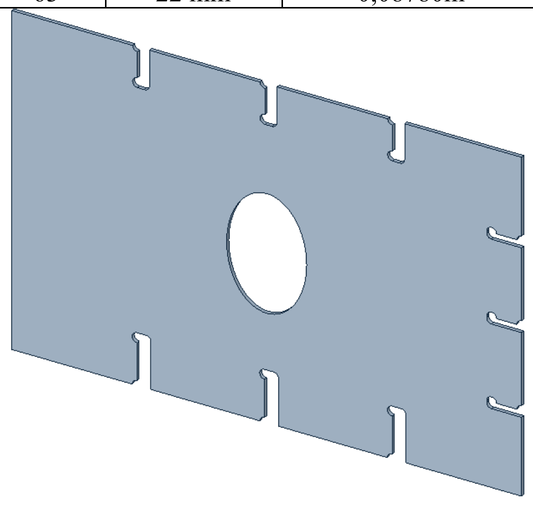


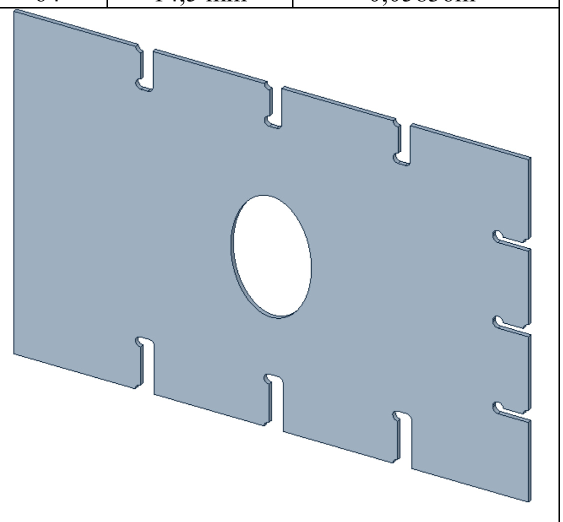
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
61	14,5 mm	0,05786m³	62	18 mm	0,07183m³



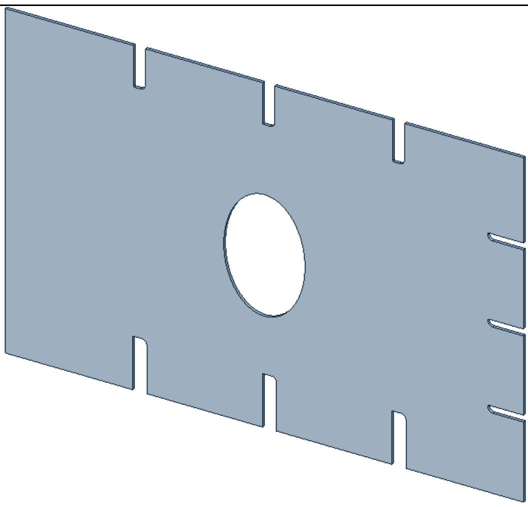


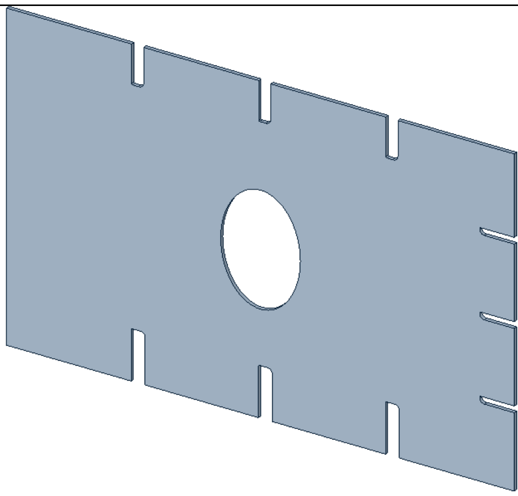
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
63	22 mm	0,08780m³	64	14,5 mm	0,05836m³



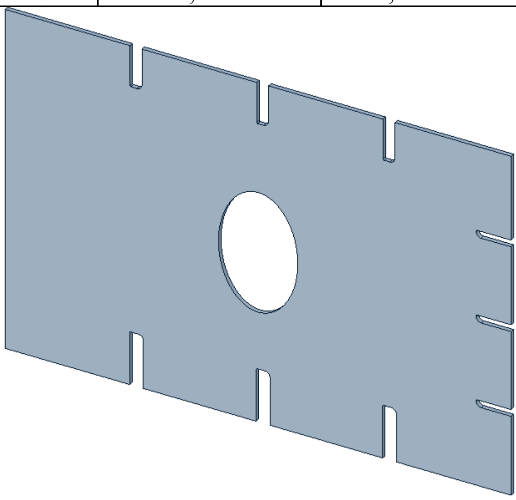


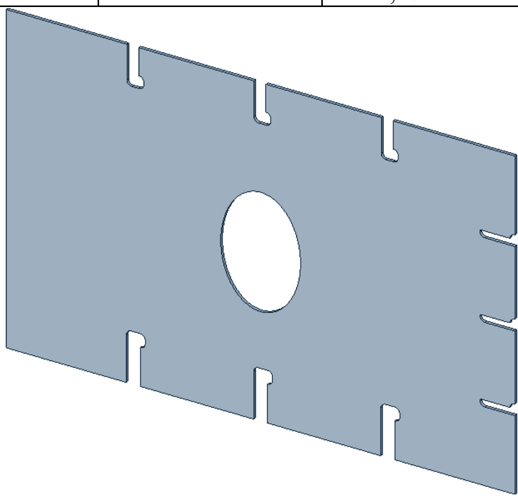
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
65	18 mm	0,07244m³	66	22 mm	0,08854m³



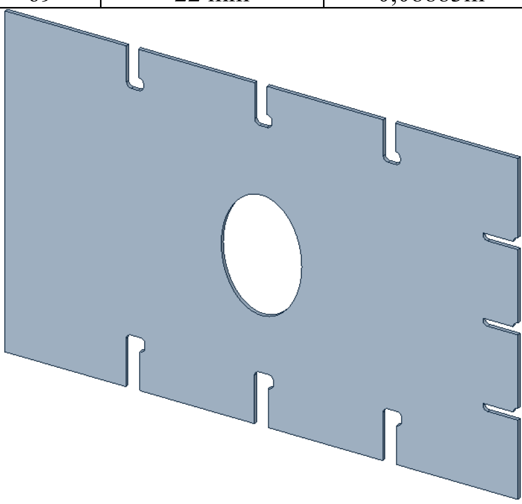


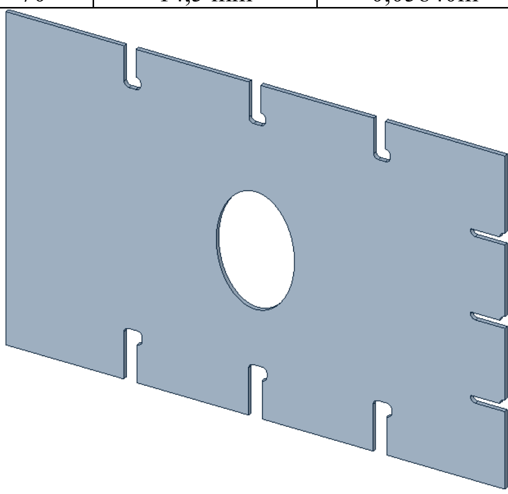
Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
67	14,5 mm	0,05855m³	68	18 mm	0,07268m³





Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
69	22 mm	0,08883m³	70	14,5 mm	0,05840m³





Nºplate	Thickness	Volume	Nºplate	Thickness	Volume
71	18 mm	0,07250m³	72	22 mm	0,08862m³

Annex II.

Shear stress

Nº	thickness (mm) and convergence (%)	stress			strain			deformation			fatigue life		
		minimun (pa)	**maximum (pa)**	**average (pa)**	**minimun (m/m)**	**maximum (m/m)**	**average (m/m)**	**minimun (m)**	**maximum (m)**	**average (m)**	**minimun (nºcycles)**	**maximum (nºcycles)**	**average (nºcycles)**
1	14,5 2,78%	6,73E+04	1,19E+08	2,75E+07	1,47E-06	5,97E-04	1,38E-04	0,00E+00	2,48E-04	9,62E-05	7,73E+04	1,00E+06	9,70E+05
2	18 2,45%	1,28E+05	9,90E+07	1,70E+07	1,32E-06	4,95E-04	8,53E-05	0,00E+00	2,00E-04	7,15E-05	1,53E+05	1,00E+06	9,98E+05
3	22 4,42%	3,64E+04	7,20E+07	1,47E+07	1,29E-06	3,60E-04	7,38E-05	0,00E+00	1,63E-04	6,06E-05	6,53E+05	1,00E+06	1,00E+06
4	14,5 3,62%	4,57E+04	1,18E+08	2,00E+07	6,48E-07	5,89E-04	1,01E-04	0,00E+00	2,48E-04	7,38E-05	6,43E+04	1,00E+06	9,92E+05
5	18 4,07%	2,00E+04	9,01E+07	1,51E+07	1,00E-07	4,51E-04	7,62E-05	0,00E+00	2,00E-04	6,96E-05	2,24E+05	1,00E+06	9,99E+05
6	22 -2,17%	2,84E+04	7,44E+07	1,23E+07	1,42E-07	3,72E-04	6,20E-05	0,00E+00	1,63E-04	5,68E-05	6,77E+05	1,00E+06	1,00E+06
7	14,5 2,86%	5,28E+04	2,21E+08	3,22E+07	4,84E-07	1,10E-03	1,62E-04	0,00E+00	2,38E-04	7,41E-05	8,76E+03	1,00E+06	8,99E+05
8	18 1,65%	4,66E+04	1,76E+08	1,86E+07	3,19E-07	8,80E-04	9,38E-05	0,00E+00	1,91E-04	6,31E-05	1,88E+04	1,00E+06	9,84E+05
9	22 2,66%	8,52E+04	1,42E+08	1,61E+07	6,74E-07	7,10E-04	8,12E-05	0,00E+00	1,56E-04	5,36E-05	4,10E+04	1,00E+06	9,92E+05
10	14,5 -1,08%	1,43E+04	2,10E+08	2,44E+07	3,11E-07	1,05E-03	1,23E-04	0,00E+00	2,36E-04	8,71E-05	1,03E+04	1,00E+06	9,67E+05
11	18 3,39%	4,37E+04	1,58E+08	1,80E+07	3,47E-07	7,93E-04	9,10E-05	0,00E+00	1,90E-04	7,63E-05	2,78E+04	1,00E+06	9,90E+05
12	22 0,01%	4,77E+04	1,39E+08	1,70E+07	3,05E-07	6,95E-04	8,53E-05	0,00E+00	1,55E-04	5,76E-05	4,44E+04	1,00E+06	9,91E+05
13	14,5 2,91%	5,05E+04	1,12E+08	2,35E+07	1,13E-06	5,61E-04	1,18E-04	0,00E+00	2,50E-04	8,71E-05	9,77E+04	1,00E+06	9,89E+05
14	18 -4,29%	6,33E+04	9,74E+07	1,80E+07	1,03E-06	4,87E-04	9,08E-05	0,00E+00	2,01E-04	7,84E-05	1,62E+05	1,00E+06	9,96E+05
15	22 2,53%	3,09E+04	7,86E+07	1,90E+07	6,17E-07	3,93E-04	9,50E-05	0,00E+00	1,64E-04	5,61E-05	4,93E+05	1,00E+06	9,99E+05
16	14,5 3,97%	4,92E+04	1,11E+08	1,87E+07	5,97E-07	5,56E-04	9,44E-05	0,00E+00	2,49E-04	9,14E-05	1,01E+05	1,00E+06	9,97E+05
17	18 1,18%	6,97E+04	9,82E+07	1,59E+07	5,18E-07	4,91E-04	8,02E-05	0,00E+00	2,00E-04	6,27E-05	1,58E+05	1,00E+06	9,98E+05
18	22 -0,85%	3,92E+04	7,80E+07	1,27E+07	2,03E-07	3,90E-04	6,37E-05	0,00E+00	1,64E-04	5,06E-05	5,16E+05	1,00E+06	1,00E+06
19	14,5 1,68%	6,88E+04	2,20E+08	2,55E+07	6,54E-07	1,10E-03	1,28E-04	0,00E+00	2,38E-04	8,01E-05	8,83E+03	1,00E+06	9,63E+05
20	18 1,13%	3,75E+04	1,70E+08	1,89E+07	4,63E-07	8,53E-04	9,53E-05	0,00E+00	1,92E-04	5,80E-05	2,10E+04	1,00E+06	9,85E+05
21	22 1,60%	3,28E+04	1,41E+08	1,51E+07	4,63E-07	7,07E-04	7,59E-05	0,00E+00	1,57E-04	4,95E-05	4,17E+04	1,00E+06	9,93E+05
22	14,5 2,97%	2,72E+04	2,17E+08	2,39E+07	3,86E-07	1,08E-03	1,20E-04	0,00E+00	2,37E-04	8,08E-05	9,25E+03	1,00E+06	9,68E+05
23	18 1,84%	4,39E+04	1,77E+08	3,02E+07	4,96E-07	8,84E-04	1,52E-04	0,00E+00	1,91E-04	6,32E-05	1,84E+04	1,00E+06	9,17E+05
24	22 0,56%	4,03E+04	1,39E+08	1,78E+07	3,10E-07	6,97E-04	8,97E-05	0,00E+00	1,56E-04	5,56E-05	4,39E+04	1,00E+06	9,90E+05
25	14,5 1,81%	5,98E+04	1,26E+08	2,51E+07	8,26E-07	6,29E-04	1,26E-04	0,00E+00	2,50E-04	8,76E-05	4,96E+04	1,00E+06	9,69E+05
26	18 1,84%	5,98E+04	1,26E+08	2,51E+07	8,26E-07	6,29E-04	1,26E-04	0,00E+00	2,50E-04	8,76E-05	6,36E+04	1,00E+06	9,73E+05
27	22 -2,26%	2,51E+04	8,35E+07	1,40E+07	1,25E-07	4,18E-04	7,02E-05	0,00E+00	1,64E-04	6,19E-05	3,48E+05	1,00E+06	9,99E+05
28	14,5 4,36%	3,37E+04	1,17E+08	2,00E+07	1,69E-07	5,84E-04	1,01E-04	0,00E+00	2,50E-04	8,55E-05	8,37E+04	1,00E+06	9,94E+05
29	18 4,67%	1,63E+04	9,50E+07	1,66E+07	1,19E-07	4,75E-04	8,38E-05	0,00E+00	2,01E-04	7,19E-05	1,78E+05	1,00E+06	9,98E+05
30	22 4,10%	3,55E+04	8,25E+07	1,31E+07	4,45E-07	4,13E-04	6,60E-05	0,00E+00	1,64E-04	5,39E-05	3,74E+05	1,00E+06	1,00E+06
31	14,5 -2,41%	1,53E+04	2,29E+08	2,50E+07	6,20E-07	1,15E-03	1,25E-04	0,00E+00	2,37E-04	7,89E-05	1,58E+04	1,00E+06	9,69E+05
32	18 4,26%	3,01E+04	1,80E+08	1,94E+07	4,07E-07	9,01E-04	9,77E-05	0,00E+00	1,91E-04	6,34E-05	1,73E+04	1,00E+06	9,79E+05
33	22 1,71%	2,27E+04	1,46E+08	1,51E+07	1,14E-07	7,31E-04	7,57E-05	0,00E+00	1,56E-04	5,06E-05	3,69E+04	1,00E+06	9,93E+05
34	14,5 1,37%	3,01E+04	2,30E+08	2,39E+07	4,10E-07	1,15E-03	1,20E-04	0,00E+00	2,35E-04	8,89E-05	7,74E+03	1,00E+06	9,68E+05
35	18 0,36%	3,47E+04	1,75E+08	1,93E+07	1,83E-07	8,74E-04	9,73E-05	0,00E+00	1,89E-04	7,31E-05	1,92E+04	1,00E+06	9,82E+05

36	22	0,57%	5,18E+04	1,49E+08	1,64E+07	5,76E-07	7,46E-04	8,25E-05	0,00E+00	1,55E-04	6,11E-05	3,41E+04	1,00E+06	9,90E+05
37	14,5	-2,02%	1,05E+05	1,27E+08	2,12E+07	1,26E-06	6,36E-04	1,06E-04	0,00E+00	2,51E-04	9,78E-05	6,12E+04	1,00E+06	9,91E+05
38	18	3,80%	8,01E+04	1,01E+08	2,24E+07	1,01E-06	5,04E-04	1,12E-04	0,00E+00	2,02E-04	6,86E-05	1,43E+05	1,00E+06	9,91E+05
39	22	3,38%	1,01E+05	7,55E+07	1,45E+07	8,49E-07	3,78E-04	7,28E-05	0,00E+00	1,65E-04	6,53E-05	6,21E+05	1,00E+06	1,00E+06
40	14,5	4,86%	5,72E+04	1,18E+08	2,07E+07	2,86E-07	5,91E-04	1,04E-04	0,00E+00	2,50E-04	7,96E-05	8,04E+04	1,00E+06	9,88E+05
41	18	4,51%	2,88E+04	9,58E+07	1,53E+07	1,44E-07	4,79E-04	7,69E-05	0,00E+00	2,02E-04	6,93E-05	1,72E+05	1,00E+06	9,99E+05
42	:22	-1,86%	8,94E+04	8,38E+07	1,49E+07	1,02E-06	4,19E-04	7,47E-05	0,00E+00	1,65E-04	5,85E-05	3,41E+05	1,00E+06	9,99E+05
43	14,5	1,06%	4,21E+04	2,31E+08	2,20E+07	6,16E-07	1,15E-03	1,11E-04	0,00E+00	2,37E-04	7,55E-05	7,62E+03	1,00E+06	9,72E+05
44	18	4,60%	3,40E+04	1,76E+08	1,75E+07	5,14E-07	8,84E-04	8,85E-05	0,00E+00	1,91E-04	7,09E-05	1,86E+04	1,00E+06	9,91E+05
45	22	1,35%	2,17E+04	1,47E+08	1,54E+07	1,08E-07	7,34E-04	7,72E-05	0,00E+00	1,56E-04	5,21E-05	3,64E+04	1,00E+06	9,92E+05
46	14,5	2,02%	3,48E+04	2,24E+08	2,39E+07	6,50E-07	1,12E-03	1,20E-04	0,00E+00	2,36E-04	8,98E-05	8,38E+03	1,00E+06	9,67E+05
47	18	4,17%	4,09E+04	1,81E+08	1,88E+07	2,28E-07	9,05E-04	9,46E-05	0,00E+00	1,90E-04	7,16E-05	1,70E+04	1,00E+06	9,82E+05
48	22	4,48%	4,83E+04	1,47E+08	1,57E+07	5,64E-07	7,33E-04	7,92E-05	0,00E+00	1,56E-04	5,64E-05	3,65E+04	1,00E+06	9,91E+05
49	14,5	-0,66%	8,23E+04	1,02E+08	2,11E+07	4,98E-07	5,10E-04	1,06E-04	0,00E+00	2,27E-04	8,34E-05	1,38E+05	1,00E+06	9,94E+05
50	18	2,10%	7,84E+04	8,23E+07	1,58E+07	4,77E-07	4,12E-04	7,93E-05	0,00E+00	1,83E-04	6,65E-05	3,78E+05	1,00E+06	9,99E+05
51	22	0,01%	5,32E+04	6,68E+07	1,30E+07	3,48E-07	3,34E-04	6,56E-05	0,00E+00	1,49E-04	5,84E-05	1,00E+06	1,00E+06	1,00E+06
52	14,5	2,71%	6,49E+04	9,73E+07	1,88E+07	4,08E-07	4,87E-04	9,44E-05	0,00E+00	2,27E-04	8,26E-05	1,63E+05	1,00E+06	9,97E+05
53	18	3,20%	4,39E+04	7,59E+07	2,09E+07	2,68E-07	3,80E-04	1,05E-04	0,00E+00	1,73E-04	7,37E-05	6,02E+05	1,00E+06	9,99E+05
54	22	2,79%	4,09E+04	6,37E+07	1,28E+07	2,68E-07	3,18E-04	6,44E-05	0,00E+00	1,49E-04	4,91E-05	1,00E+06	1,00E+06	1,00E+06
55	14,5	2,16%	6,21E+04	1,81E+08	2,26E+07	5,97E-07	9,07E-04	1,13E-04	0,00E+00	2,18E-04	7,86E-05	1,69E+04	1,00E+06	9,81E+05
56	18	3,13%	7,04E+04	1,37E+08	1,64E+07	4,78E-07	6,85E-04	8,24E-05	0,00E+00	1,66E-04	5,25E-05	4,69E+04	1,00E+06	9,95E+05
57	22	1,62%	3,65E+04	1,19E+08	1,90E+07	1,83E-07	5,94E-04	9,53E-05	0,00E+00	1,43E-04	5,15E-05	7,86E+04	1,00E+06	9,88E+05
58	14,5	2,15%	4,69E+04	1,79E+08	2,60E+07	5,01E-07	8,97E-04	1,30E-04	0,00E+00	2,16E-04	8,23E-05	1,75E+04	1,00E+06	9,57E+05
59	18	2,63%	2,05E+04	1,36E+08	1,79E+07	1,02E-07	6,82E-04	9,01E-05	0,00E+00	1,65E-04	6,20E-05	4,79E+04	1,00E+06	9,92E+05
60	22	-1,91%	2,92E+04	1,18E+08	1,66E+07	2,20E-07	5,92E-04	8,34E-05	0,00E+00	1,42E-04	5,08E-05	7,95E+04	1,00E+06	9,90E+05
61	14,5	3,59%	4,05E+04	1,43E+08	2,85E+07	5,41E-07	7,15E-04	1,43E-04	0,00E+00	2,96E-04	9,91E-05	3,98E+04	1,00E+06	9,46E+05
62	18	3,54%	3,04E+04	1,15E+08	2,09E+07	3,00E-07	5,77E-04	1,05E-04	0,00E+00	2,38E-04	7,27E-05	8,73E+04	1,00E+06	9,84E+05
63	22	0,98%	5,37E+04	9,36E+07	1,44E+07	2,69E-07	4,68E-04	7,22E-05	0,00E+00	1,95E-04	6,42E-05	1,88E+05	1,00E+06	9,98E+05
64	14,5	1,80%	6,27E+04	1,45E+08	2,20E+07	3,13E-07	7,26E-04	1,11E-04	0,00E+00	2,95E-04	9,29E-05	3,77E+04	1,00E+06	9,83E+05
65	18	1,82%	5,07E+04	1,16E+08	2,01E+07	3,72E-07	5,79E-04	1,01E-04	0,00E+00	2,38E-04	7,21E-05	8,65E+04	1,00E+06	9,84E+05
66	22	4,23%	5,49E+04	8,48E+07	1,30E+07	4,67E-07	4,26E-04	6,55E-05	0,00E+00	1,94E-04	6,18E-05	3,18E+05	1,00E+06	9,99E+05
67	14,5	3,68%	4,63E+04	2,58E+08	2,51E+07	5,25E-07	1,29E-03	1,26E-04	0,00E+00	2,78E-04	8,09E-05	5,37E+03	1,00E+06	9,69E+05
68	18	-1,01%	3,07E+04	2,12E+08	2,82E+07	1,61E-07	1,06E-03	1,41E-04	0,00E+00	2,24E-04	6,93E-05	9,86E+03	1,00E+06	9,18E+05
69	22	2,48%	1,74E+04	1,70E+08	1,78E+07	1,06E-07	8,48E-04	8,98E-05	0,00E+00	1,83E-04	5,89E-05	2,13E+04	1,00E+06	9,80E+05
70	14,5	0,01%	3,01E+04	2,60E+08	3,44E+07	3,32E-07	1,30E-03	1,73E-04	0,00E+00	2,77E-04	9,35E-05	5,27E+03	1,00E+06	8,95E+05
71	18	2,82%	9,92E+03	2,08E+08	2,25E+07	1,10E-07	1,04E-03	1,13E-04	0,00E+00	2,23E-04	8,02E-05	1,05E+04	1,00E+06	9,65E+05
72	22	3,92%	6,45E+04	1,45E+08	1,51E+07	4,33E-07	7,26E-04	7,64E-05	0,00E+00	1,82E-04	6,90E-05	3,77E+04	1,00E+06	9,93E+05

Bending moments

		stress			strain			deformation			fatigue life		
Nº	**thickness (mm) and convergence (%)**	**minimun (pa)**	**maximum (pa)**	**average (pa)**	**minimun (m/m)**	**maximum (m/m)**	**average (m/m)**	**minimun (m)**	**maximum (m)**	**average (m)**	**minimun (nºcycles)**	**maximum (nºcycles)**	**average (nºcycles)**
1	14,5 1,60%	9,76E+04	1,57E+08	3,15E+07	1,96E-06	7,87E-04	1,85E-04	0,00E+00	6,01E-02	1,75E-02	5,38E+04	1,00E+06	9,95E+05
2	18 1,95%	7,92E+04	1,23E+08	1,98E+07	9,31E-07	6,16E-04	1,12E-04	0,00E+00	3,18E-02	9,18E-03	1,31E+05	1,00E+06	9,99E+05
3	22 2,75%	4,05E+04	8,41E+07	1,47E+07	6,95E-07	4,21E-04	8,02E-05	0,00E+00	1,75E-02	4,39E-03	9,20E+05	1,00E+06	1,00E+06
4	14,5 -0,79%	6,88E+04	1,84E+08	3,38E+07	1,39E-06	9,27E-04	2,07E-04	0,00E+00	6,03E-02	1,37E-02	3,04E+04	1,00E+06	9,88E+05
5	18 0,53%	5,81E+04	1,28E+08	2,45E+07	7,35E-07	6,39E-04	1,29E-04	0,00E+00	3,18E-02	6,94E-03	1,14E+05	1,00E+06	9,93E+05
6	22 -2,00%	2,81E+04	8,76E+07	1,46E+07	5,98E-07	4,38E-04	7,63E-05	0,00E+00	1,74E-02	4,35E-03	7,28E+05	1,00E+06	1,00E+06
7	14,5 2,09%	8,52E+04	3,17E+08	3,74E+07	1,07E-06	1,58E-03	2,09E-04	0,00E+00	6,05E-02	1,47E-02	4,93E+03	1,00E+06	9,54E+05
8	18 2,07%	2,53E+04	2,13E+08	2,64E+07	6,73E-07	1,06E-03	1,41E-04	0,00E+00	3,17E-02	8,61E-03	1,78E+04	1,00E+06	9,61E+05
9	22 2,60%	2,92E+04	1,40E+08	1,61E+07	3,13E-07	7,00E-04	8,08E-05	0,00E+00	1,51E-04	5,19E-05	8,67E+04	1,00E+06	9,96E+05
10	14,5 0,39%	7,88E+04	3,13E+08	3,27E+07	8,49E-07	1,57E-03	1,82E-04	0,00E+00	6,07E-02	1,79E-02	2,03E+03	1,00E+06	9,04E+05
11	18 2,95%	4,35E+04	2,06E+08	2,58E+07	5,85E-07	1,03E-03	1,36E-04	0,00E+00	3,18E-02	8,23E-03	2,00E+04	1,00E+06	9,68E+05
12	22 4,48%	2,83E+04	1,45E+08	1,47E+07	5,57E-07	7,23E-04	7,94E-05	0,00E+00	1,74E-02	4,87E-03	7,29E+04	1,00E+06	9,99E+05
13	14,5 -0,07%	6,17E+04	1,96E+08	3,30E+07	1,26E-06	9,81E-04	1,77E-04	0,00E+00	6,19E-02	1,30E-02	2,38E+04	1,00E+06	9,82E+05
14	18 3,54%	6,79E+04	1,20E+08	2,23E+07	8,33E-07	6,00E-04	1,21E-04	0,00E+00	3,22E-02	7,15E-03	1,44E+05	1,00E+06	9,98E+05
15	22 0,18%	4,69E+04	8,17E+07	1,48E+07	7,78E-07	4,09E-04	8,04E-05	0,00E+00	1,77E-02	4,26E-03	1,00E+06	1,00E+06	1,00E+06
16	14,5 1,20%	5,04E+04	1,77E+08	3,17E+07	5,94E-07	8,90E-04	1,87E-04	0,00E+00	6,10E-02	1,65E-02	3,45E+04	1,00E+06	9,87E+05
17	18 0,55%	2,05E+04	1,28E+08	2,36E+07	5,59E-07	6,38E-04	1,23E-04	0,00E+00	3,21E-02	6,47E-03	1,15E+05	1,00E+06	9,96E+05
18	22 -0,07%	2,77E+04	8,53E+07	1,54E+07	3,84E-07	4,27E-04	8,02E-05	0,00E+00	1,76E-02	3,79E-03	8,46E+05	1,00E+06	1,00E+06
19	14,5 -0,09%	5,67E+04	3,23E+08	3,75E+07	7,96E-07	1,62E-03	2,02E-04	0,00E+00	6,10E-02	1,72E-02	2,69E+03	1,00E+06	9,01E+05
20	18 2,07%	5,19E+04	2,12E+08	2,37E+07	7,84E-07	1,06E-03	1,31E-04	0,00E+00	3,19E-02	7,60E-03	1,81E+04	1,00E+06	9,87E+05
21	22 3,11%	4,67E+04	1,36E+08	1,58E+07	3,43E-07	6,79E-04	8,55E-05	0,00E+00	1,75E-02	4,06E-03	9,18E+04	1,00E+06	9,99E+05
22	14,5 2,54%	6,46E+04	2,79E+08	3,56E+07	5,40E-07	1,40E-03	2,14E-04	0,00E+00	6,10E-02	1,53E-02	7,30E+03	1,00E+06	9,70E+05
23	18 -0,90%	2,66E+04	2,13E+08	2,56E+07	6,70E-07	1,07E-03	1,35E-04	0,00E+00	3,21E-02	7,69E-03	1,77E+04	1,00E+06	9,71E+05
24	22 -4,97%	4,06E+04	1,44E+08	1,61E+07	5,51E-07	7,21E-04	8,75E-05	0,00E+00	1,76E-02	4,33E-03	7,38E+04	1,00E+06	9,99E+05
25	14,5 -0,22%	7,92E+04	1,87E+08	3,39E+07	9,20E-07	9,38E-04	1,91E-04	0,00E+00	6,08E-02	1,39E-02	2,83E+04	1,00E+06	9,83E+05
26	18 -0,22%	7,92E+04	1,87E+08	3,39E+07	9,20E-07	9,38E-04	1,91E-04	0,00E+00	6,08E-02	1,39E-02	2,83E+04	1,00E+06	9,83E+05
27	22 3,81%	4,83E+04	8,41E+07	1,46E+07	5,77E-07	4,21E-04	8,06E-05	0,00E+00	1,75E-02	5,00E-03	9,20E+05	1,00E+06	1,00E+06
28	14,5 4,66%	9,25E+04	1,86E+08	3,51E+07	1,92E-06	9,29E-04	2,08E-04	0,00E+00	6,02E-02	1,21E-02	2,93E+04	1,00E+06	9,87E+05
29	18 4,12%	4,30E+04	1,24E+08	2,11E+07	8,74E-07	6,19E-04	1,16E-04	0,00E+00	3,17E-02	8,14E-03	1,29E+05	1,00E+06	9,98E+05
30	22 0,94%	3,79E+04	8,67E+07	1,71E+07	5,14E-07	4,34E-04	9,22E-05	0,00E+00	1,74E-02	3,52E-03	7,70E+05	1,00E+06	1,00E+06
31	14,5 1,43%	4,52E+04	3,12E+08	3,36E+07	8,23E-07	1,56E-03	2,12E-04	0,00E+00	6,05E-02	1,91E-02	4,74E+03	1,00E+06	9,69E+05
32	18 -0,98%	5,15E+04	2,09E+08	2,64E+07	7,28E-07	1,05E-03	1,41E-04	0,00E+00	3,16E-02	8,69E-03	1,88E+04	1,00E+06	9,58E+05
33	22 1,09%	4,63E+04	1,34E+08	1,52E+07	6,25E-07	6,73E-04	9,23E-05	0,00E+00	1,72E-02	4,89E-03	9,52E+04	1,00E+06	9,99E+05
34	14,5 -0,31%	4,82E+04	3,20E+08	3,46E+07	5,91E-07	1,60E-03	1,93E-04	0,00E+00	6,07E-02	1,61E-02	4,76E+03	1,00E+06	9,64E+05
35	18 1,16%	4,01E+04	2,12E+08	2,69E+07	5,48E-07	1,06E-03	1,43E-04	0,00E+00	3,17E-02	7,82E-03	1,82E+04	1,00E+06	9,61E+05
36	22 1,70%	6,61E+04	1,44E+08	1,68E+07	5,66E-07	7,22E-04	9,28E-05	0,00E+00	1,74E-02	4,39E-03	7,35E+04	1,00E+06	9,98E+05

37	14,5	2,35%	6,45E+04	1,90E+08	3,48E+07	7,97E-07	9,50E-04	1,90E-04	0,00E+00	6,16E-02	1,30E-02	2,68E+04	1,00E+06	9,75E+05
38	18	3,10%	5,97E+04	1,23E+08	2,14E+07	8,07E-07	6,16E-04	1,14E-04	0,00E+00	3,23E-02	7,48E-03	1,31E+05	1,00E+06	9,98E+05
39	22	-1,18%	6,01E+04	8,40E+07	1,59E+07	5,28E-07	4,20E-04	8,54E-05	0,00E+00	1,77E-02	3,32E-03	9,24E+05	1,00E+06	1,00E+06
40	14,5	4,91%	6,64E+04	1,82E+08	3,45E+07	9,35E-07	9,10E-04	2,04E-04	0,00E+00	6,05E-02	1,39E-02	3,15E+04	1,00E+06	9,84E+05
41	18	-0,03%	6,01E+04	1,23E+08	2,03E+07	7,09E-07	6,13E-04	1,12E-04	0,00E+00	3,20E-02	8,29E-03	1,33E+05	1,00E+06	9,98E+05
42	22	-2,32%	2,95E+04	8,60E+07	1,54E+07	3,03E-07	4,30E-04	8,14E-05	0,00E+00	1,76E-02	4,09E-03	8,11E+05	1,00E+06	1,00E+06
43	14,5	0,48%	6,93E+04	3,16E+08	3,77E+07	6,55E-07	1,58E-03	2,18E-04	0,00E+00	6,08E-02	1,43E-02	4,94E+03	1,00E+06	9,55E+05
44	18	1,39%	3,04E+04	2,07E+08	2,49E+07	4,91E-07	1,03E-03	1,32E-04	0,00E+00	3,19E-02	7,24E-03	1,97E+04	1,00E+06	9,75E+05
45	22	1,13%	4,68E+04	1,40E+08	1,71E+07	5,64E-07	7,00E-04	9,44E-05	0,00E+00	1,74E-02	3,69E-03	8,23E+04	1,00E+06	9,98E+05
46	14,5	4,18%	8,31E+04	3,04E+08	3,47E+07	7,74E-07	1,53E-03	2,10E-04	0,00E+00	6,09E-02	1,57E-02	5,57E+03	1,00E+06	9,73E+05
47	18	-0,05%	8,23E+04	2,08E+08	2,64E+07	5,48E-07	1,04E-03	1,45E-04	0,00E+00	3,20E-02	6,03E-03	1,92E+04	1,00E+06	9,81E+05
48	22	0,51%	4,49E+04	1,45E+08	1,77E+07	5,79E-07	7,27E-04	9,32E-05	0,00E+00	1,76E-02	3,48E-03	7,15E+04	1,00E+06	9,97E+05
49	14,5	1,23%	4,10E+04	1,87E+08	3,34E+07	7,88E-07	9,36E-04	1,76E-04	0,00E+00	6,10E-02	1,36E-02	2,83E+04	1,00E+06	9,69E+05
50	18	1,56%	4,63E+04	1,22E+08	2,19E+07	6,14E-07	6,12E-04	1,16E-04	0,00E+00	3,19E-02	7,33E-03	1,34E+05	1,00E+06	9,98E+05
51	22	4,35%	4,74E+04	8,62E+07	1,36E+07	7,61E-07	4,31E-04	7,29E-05	0,00E+00	1,74E-02	4,86E-03	7,98E+05	1,00E+06	1,00E+06
52	14,5	-0,10%	4,09E+04	1,92E+08	3,38E+07	5,14E-07	9,58E-04	1,83E-04	0,00E+00	6,06E-02	1,64E-02	2,60E+04	1,00E+06	9,52E+05
53	18	0,45%	3,91E+04	1,13E+08	2,41E+07	5,26E-07	5,63E-04	1,24E-04	0,00E+00	2,70E-02	5,33E-03	1,81E+05	1,00E+06	9,98E+05
54	22	-0,79%	3,23E+04	8,41E+07	1,50E+07	3,34E-07	4,21E-04	7,89E-05	0,00E+00	1,74E-02	4,24E-03	9,19E+05	1,00E+06	1,00E+06
55	14,5	2,99%	5,43E+04	3,01E+08	4,04E+07	7,81E-07	1,51E-03	2,17E-04	0,00E+00	6,03E-02	1,49E-02	5,75E+03	1,00E+06	9,24E+05
56	18	-3,90%	4,02E+04	1,74E+08	2,18E+07	6,08E-07	8,71E-04	1,14E-04	0,00E+00	2,68E-02	6,68E-03	3,69E+04	1,00E+06	9,85E+05
57	22	-0,96%	2,06E+04	1,36E+08	1,73E+07	5,71E-07	6,79E-04	9,63E-05	0,00E+00	1,73E-02	3,83E-03	9,17E+04	1,00E+06	9,99E+05
58	14,5	-1,24%	7,78E+04	2,74E+08	3,50E+07	8,28E-07	1,37E-03	2,17E-04	0,00E+00	6,02E-02	1,49E-02	7,71E+03	1,00E+06	9,77E+05
59	18	0,80%	4,16E+04	1,82E+08	2,36E+07	8,20E-07	9,10E-04	1,33E-04	0,00E+00	2,68E-02	5,97E-03	3,14E+04	1,00E+06	9,90E+05
60	22	3,47%	4,21E+04	1,32E+08	1,87E+07	3,22E-07	6,58E-04	1,00E-04	0,00E+00	1,74E-02	3,70E-03	1,03E+05	1,00E+06	9,97E+05
61	14,5	-0,38%	7,72E+04	2,06E+08	3,22E+07	1,22E-06	1,03E-03	2,00E-04	0,00E+00	6,22E-02	1,86E-02	1,99E+04	1,00E+06	9,80E+05
62	18	-3,67%	5,15E+04	1,35E+08	2,36E+07	3,87E-07	6,75E-04	1,30E-04	0,00E+00	3,28E-02	6,51E-03	9,46E+04	1,00E+06	9,98E+05
63	22	3,34%	4,06E+04	9,21E+07	1,53E+07	5,13E-07	4,62E-04	8,60E-05	0,00E+00	1,80E-02	3,83E-03	5,44E+05	1,00E+06	1,00E+06
64	14,5	-0,37%	8,30E+04	2,17E+08	3,39E+07	1,58E-06	1,08E-03	1,90E-04	0,00E+00	6,19E-02	1,48E-02	1,68E+04	1,00E+06	9,74E+05
65	18	1,87%	7,18E+04	1,35E+08	2,26E+07	6,47E-07	6,74E-04	1,34E-04	0,00E+00	3,23E-02	7,00E-03	9,48E+04	1,00E+06	9,98E+05
66	22	2,61%	2,23E+04	9,41E+07	1,43E+07	4,69E-07	4,70E-04	7,79E-05	0,00E+00	1,78E-02	4,37E-03	4,83E+05	1,00E+06	1,00E+06
67	14,5	4,96%	3,18E+04	2,08E+08	2,32E+07	4,37E-07	1,04E-03	1,46E-04	0,00E+00	3,85E-02	1,12E-02	1,93E+04	1,00E+06	9,89E+05
68	18	-3,96%	5,50E+04	2,30E+08	2,47E+07	5,37E-07	1,15E-03	1,36E-04	0,00E+00	3,22E-02	8,01E-03	1,36E+04	1,00E+06	9,80E+05
69	22	-4,31%	3,77E+04	1,57E+08	1,90E+07	7,13E-07	7,86E-04	1,06E-04	0,00E+00	1,77E-02	3,52E-03	5,37E+04	1,00E+06	9,95E+05
70	14,5	2,18%	4,15E+04	3,49E+08	4,30E+07	6,08E-07	1,74E-03	2,33E-04	0,00E+00	6,21E-02	1,57E-02	3,66E+03	1,00E+06	9,09E+05
71	18	4,52%	5,36E+04	2,00E+08	2,29E+07	7,31E-07	1,01E-03	1,27E-04	0,00E+00	3,24E-02	8,35E-03	2,20E+04	1,00E+06	9,92E+05
72	22	4,79%	4,32E+04	1,62E+08	1,56E+07	5,17E-07	8,11E-04	8,82E-05	0,00E+00	1,78E-02	4,28E-03	4,80E+04	1,00E+06	9,99E+05